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U. S. NAVAL AIR ENGINEERING CENTER

LAKEHURST, NEW JERSEY

GROUND SUPPORT EQUIPMENT DEPARTMENT
NAEC-GSED-106 SEPT 1976
CODE IDENT. NO. 28638

CONTROL OF CORROSION
IN
GROUND SUPPORT EQUIPMENT

AIRTASK NO. A3400000/051B/6F41461400
WORK UNIT NO. 23

INTERIM REPORT

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NAVAL AIR ENGINEERING CENTER

LAKEHURST, NEW JERSEY 08733

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A summary of efforts to provide guidelines for control of corrosion of ground support equipment. Problem definition and "state-of-the-art" investigations include findings of surveys of East and West Coast NAS/MCAS/CV sites. A comprehensive Corrosion Key analyzes the extensive photographic record from the survey. Data has been compiled relating to corrosion control methods, materials and equipment for inclusion in a NAVAIR manual specifically oriented for GSE.

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SECTION I

INTRODUCTION

1.1 The intent of this interim report is to present results of efforts to date to provide guidelines for the control of corrosion of ground support equipment (GSE). These guidelines are achieved through a twofold effort of problem definition and "state-of-the-art" investigation. The problem definition phase presents the findings of surveys of GSE corrosion at East and West Coast NAS/MCAS sites. Discussion of corrosion control problems, equipment availability, personnel attitudes and approaches to corrosion control programs are included. Present "state-of-the-art" corrosion control measures employed by the military, industrial and scientific communities relating to materials, surface preparation, paints and plastic surface coatings for GSE are being evaluated.

1.2 The survey and evaluation to provide guidelines for GSE corrosion control has objectives as follows:

a. Explore GSE corrosion identification, removal and control.

b. Develop alternatives/requirements to improve overall GSE corrosion control/maintenance efforts.

c. Develop specification criteria to inhibit and control GSE corrosion at the design/procurement levels.

d. Evaluate/develop corrosion removal equipment, corrosion barrier schemes and barrier maintenance procedures.

e. Provide inputs for a comprehensive corrosion control manual specifically oriented to GSE.

1.3 Corrosion, a natural phenomenon, is either accelerated or retarded by wind, rain and temperature variation of the environment. Efforts at corrosion control are either to provide a local controlled environment or to create a barrier to the natural corrosion process, the latter being generally used for GSE. The barrier between the bulk of GSE and encountered corrosive environmental conditions is usally provided by a paint film. Protection is provided while the paint film is intact but any scratches, impacts or abrasions heavy enough to break through the paint barrier immediately begin the corrosive process on the metal beneath, thus undermining the protective film. Restoration of film continuity arrests the corrosion process which, if left unchecked, would progress to destruction.

SECTION II

CONCLUSIONS

2.1. The following conclusions have been reached during this corrosion control program:

a. Field survey of GSE corrosion at East and West Coast NAS/MCAS sites indicate a greater awareness is required at the design level for the simple inclusion of corrosion inhibiting schemes. These schemes should consider each of the following: properly placed and large diameter drain holes; panels substituted for hinged doors; corrosion-resistant metals; either the elimination of, or a better choice of, fasteners; an improved seat design; use of gratings in foot areas; sloped deck sheets; weather shielding for casters; corrosion resistant covering for hand rails and hand touched areas; a better acid-resistant design for battery supports and enclosure areas; a positive vent system for instrument casings; elimination of the use of wood in GSE; elimination of the use of foam rubber where possible; a more durable wheel hub coating than paint; use of protective boots on piston rods; and location of components out of striking reach of riding passengers. Life cycle costing and merit of each of the above should be studied for their effect on overall procurement and maintenance costs of GSE.

b. GSE corrosion control programs at NAS/MCAS sites at present have no specific directives but rely on the expertise gained from aircraft corrosion control and self-training by experience of corrosion control personnel.

c. A wide divergence of methods and facilities used in GSE corrosion control exists from station to station. The unifying of corrosion control methods, facilities and materials will improve the quality of corrosion protection, simplify procurement of materials, reduce variety of these materials inventoried and enable establishment of a universal corrosion control training program.

d. A need exists for ways and means to make corrosion control efforts more effective. Notable among these are additional personnel, improved paint removal techniques and specific directives for optimum coating schemes.

e. The 3M Data Bank, as it currently collects data on GSE corrosion, does not provide any specifics other than to indicate total hours applied to equipment considered corroded. The data bank has proven of little value in determining malfunction due to corrosion or corrective measures taken. It does, however, give an insight into the overall dollar cost of the Navy corrosion effort.

SECTION III

APPROACH

3.1. A survey of literature and procedures on corrosion control in the Navy, spanning several years, has been undertaken to develop insight into the technical conduct of the science. This broad survey, supplemented by interviews with knowledgeable personnel including those responsible for corrosion control efforts, indicates a trend in the approach to control of corrosion. See reference (1). This trend is a growing awareness of the importance of corrosion control in all branches of the military, the industrial and scientific communities as well as the Navy. The possible savings to be effected by application of improved corrosion control methods, materials and equipment to Navy materiel is recognized. Emphasis on corrosion control has been oriented to highly sophisticated, high dollar items such as aircraft, where extension of the useful life is reflected in high dollar savings. Documentation exists for Navy aircraft corrosion control but there is none specifically for ground support equipment.

3.2. For a number of years, the principal Navy document in use as a guide to corrosion control of GSE has been NAVAIR 01-1A-509 Technical Manual Aircraft Weapons Systems Cleaning and Corrosion Control, Organizational and Intermediate, 15 March 1972. This manual has been used very successfully as a training text for squadron personnel in that it provides a background in the principles of corrosion and its prevention. It also outlines step by step procedures to be followed in order to maintain relatively corrosion free aircraft during deployment. It deals with general instructions for corrosion control describing necessary elements in conducting an effective corrosion control program and pinpointing common trouble areas in most aircraft. The manual contains sections dealing with Preventive Maintenance, Emergency Procedures, Evaluation and Treatment of Corroded Areas, Paint Finishes and Touchup Procedures, and Equipment Used for Aircraft Cleaning and Corrosion Control. These sections are very specific and comprehensive insofar as aircraft corrosion is concerned but there is a mere mention of GSE here and there, and then in most general terms. Also the document, almost totally oriented toward aircraft corrosion, primarily treats corrosion of aluminum alloys, see reference (2).

3.3. In GSE the principal material is commercial grade steel plate and other forms of steel and therefore requires a different treatment than spelled out for aircraft fabricated principally of aluminum. The specific instructions in step by step procedures included in the 509 manual for aircraft are not necessarily applicable to GSE and no such instructions are included for GSE. For this reason the desirability and need for a specifically GSE oriented manual along the lines of the 509 has been voiced from many quarters in the Navy.

3.4. The storage, handling and use of GSE is almost invariably in an environment which fosters corrosion. Because of the volume of GSE with its consequent large storage area requirement it is usually stored under open skies. Handling and use of

the bulk of GSE is also principally out of doors where the equipment is exposed to rain, salt, sun, airborne particles, fluctuating temperature and corrosive exhaust gases all of which are conducive to corrosion, see reference (3).

3.4.1. Open skies storage, the norm for GSE, begins in most instances with delivery of the equipment from the manufacturer. Frequently parts must be replaced or refurbished before a piece of new equipment can be issued because of the open sky storage practice. Following issue, the corrosive process is resumed because the use environment of the bulk of GSE is also under open skies. This environmentally induced corrosion may be slowed by zealous corrosion maintenance, improved surface coatings, and at the design phase, removal of possible water traps and provision of adequate drainage and ventilation.

3.4.2. Because GSE is operational in extremes of weather from various geographical areas, it was hoped that correlation of data on corrosion with weather patterns of the environment could be made. Constant fluctuations in weather patterns and the lack of specific corrosion data from the 3-M Data Bank made the first attempt at such correlation of little value. The subsequent East and West coast field surveys produced a photographic record that does tie in with environmental conditions meaningfully.

3.5. The 3-M Data Bank was searched for corrosion entries for a current two year period in an effort to extract specific corrosion data for the extensive roster of GSE. Based on the meager quantity and quality of corrosion entries in the Bank for GSE, it was not possible to pinpoint the existence of GSE corrosion problems. The broad categorization applied in GSE corrosion reporting together with the practice of combining corrosion with other maintenance activity are the reasons the 3-M Data Bank did not provide the hoped for data. Reference (3) details the search and it is also explained more briefly in Section V.

3.6. Because specific corrosion data was not forthcoming from 3-M Data, field surveys of East and West Coast sites were made to: (1) provide photo documentation of corrosion problems, (2) study methods and materials used in corrosion control efforts, and (3) study the needs expressed by responsible personnel toward improvement in their corrosion control programs. The results of the field surveys are detailed in Section V and Appendix B.

3.7. The East Coast Site field survey included the following:

NAS Key West
NAS Pensacola
NAS Whiting
NARF/NAS Jacksonville
MCAS Beaufort
NARF/NAS Norfolk
NAS Oceana

The West Coast Site field survey included the following:

NARF/NAS North Island
NAS Miramar
MCAS El Toro
NAS Moffet
NARF/NAS Alameda
NAS Whidbey Island

In addition to the above coastal sites, the GSE from USS INDEPENDENCE was field surveyed during offloading at termination of a seven month winter deployment which began with six weeks in the North Atlantic. The scope of the survey spans from the Tropic to Near Arctic environment and covers any and all GSE located at the sites surveyed.

3.8. Specific data obtained includes approximately 750 photos detailing numerous instances of corrosion which are broken down into a Corrosion Key (figure 5-8) comprised of 17 categories. Examples of each category are pictured in selected photos with a description of the category. A tabulation of corrosion incidents using the Corrosion Key is presented in Appendix B for purposes of comparison, evaluation and determining trends relating to equipment and location.

3.9. Corrosion removal methods and equipment have been discussed with cognizant personnel at each site surveyed and the preferences stated cover the field. Each of the following are accepted methods of corrosion removal in some stations: chemical paint stripping, disc sanding, wire brush, wet or dry sanding, sand blast, and "Hydroblaster". The desirability of standardization of corrosion removal methods and equipment have been stated by personnel on both coasts. The projected GSE Corrosion Control Manual will include recommended methods and equipment presently being evaluated. Consideration is being given to the various method and equipment requirements between "zero time rehabilitation" as performed at NARF's and the NAS/MCAS squadron corrosion removal efforts.

3.10. An investigation into the durability and cost effectiveness of surface coatings is in process at NADC, Johnsville and NARF Materials Engineering Division, Alameda. Lacquer, enamel, epoxy paint, polyurethane paint, nylon and ABS coatings are being considered and findings will be presented in the final engineering report.

3.11. The results of investigation into the toxicity and other application problems of surface coatings considering time, manpower and equipment requirements will also be presented in a final engineering report.

SECTION IV

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SECTION V

CONTROL OF CORROSION IN GROUND SUPPORT EQUIPMENT

5.1. This report summarizes the findings from a two year effort into the corrosion situation in ground support equipment.

5.2. Initially a survey of corrosion correspondence traffic was undertaken to obtain an insight into the nature and handling of problems attributed to corrosion in GSE. The message traffic concerning GSE corrosion was of no significant volume. The survey was then expanded to include the following: A bibliography search, a review of recent years Navy-sponsored meetings relating to broad base corrosion, visits to several AIRLANT facilities for first-hand comment on the field attitude towards GSE corrosion, attendance at a Tri-Service conference on the corrosion of Military equipment, and an amassing of trade literature on current equipment, processes and materials for the inhibition, removal, and control of corrosion.

5.2.1. The bibliography search, covering more than a five year period indicated the meager nature and extent of corrosion reporting as no reports were found relating specifically to corrosion of GSE. A second search in 1976 included but one such report, an interim report (see reference (3)) issued under the present task, reporting status of this NAVAIR funded program. The bulk of reports were from Kennedy Space Center and dealt with corrosion problems attributed to rocket exhaust gases and related malfunctions.

5.2.2. A visit to the AIRLANT office at Norfolk was made to obtain some comments from field personnel handling GSE removed from carriers at the end of deployment. Some of the more pertinent comments from this visit are reiterated here:

a. The call-out of applicable MIL specs for the corrosion protection of GSE appears to be lax in drawings and contracts. The protection scheme, other than in broad general statements, apparently is left to the established practices of the manufacturer. In checking this out, we found that equipment designed at NAEC generally specified reference (4) for the schedule of protective finishes to be provided as the corrosion barrier. Reference (5) also is used, to a lesser extent however. The schedules provide only for the initial protective scheme. It should be noted, the Standard was written by USAF.

b. Primer plus a top coat of paint very often defines the protection on surfaces exposed to view. Inaccessible areas may receive only a primer coat at manufacture, and seldom, if ever, any follow-up coating maintenance in the field. As a result, much of the most severe corrosion occurs from the inside out. Entire panels frequently require replacement because of this unchecked corrosion field.

c. The carrier environment is the most conducive to corrosion.

d. Corrosion-handling facilities, both sea and land-based, for the most part, are not proper or adequate.

e. Deterioration of LOX equipment is particularly severe; armament support gear has a similarly fast corrosion rate.

f. The personnel shortage and the accent on aircraft in corrosion training (per NAVAIR 01-1A-509) share much of the responsibility for the lack of quality of GSE corrosion protection.

g. Storage of GSE under open skies is a major factor to the initiation and continuance of the corrosion process.

5.2.3. A Tri-Service conference on the corrosion of military equipment was held in Dayton, Ohio, 29 through 31 October 1974. At this meeting, the Air Force emphasized a philosophical approach they have developed and implemented towards corrosion of "prevent" rather than "cure". Their corrosion program has been expanded to involve all levels of management. It operates under such basic guidelines as:

a. The establishment of acquisition regulations for new material where corrosion has now been made a must consideration.

b. Identification of problems stemming from corrosion that they may be analyzed and handled by a team of corrosion experts.

c. Expansion of corrosion programs to accent the significance of a prevent rather than a cure theme.

d. Advance anticipation and coordination of corrosion items in order to improve and delineate standardized solutions.

e. The establishment of data systems to provide data bank information and versatility for the solution of corrosion problems.

f. A motivation of the industry to a corrosion awareness for the needs of the military and the relation of operational function to corrosion.

g. The recognition and establishment of interface transfers of corrosion cognizance between responsibility groups associated with the various life phases of an article from manufacture to eventual phase out.

5.2.4. Trade literature has been gathered over a period of months on equipment, processes and materials related to the corrosion control effort. A tabulation of each appears in Appendix A with evaluation for those for which data has been established.

The tabulation is presented in three tables: Table I, Equipment; Table II, Processes; and Table III, Materials. A complete treatment of each of these will be made for the GSE Corrosion Control Manual.

5.3. Reference (6) describes a tour of the seven NARF depots (1972) with detailed description and analyses of operations related to the removal of coatings, corrosion removal and application of surface treatments and protective coatings to aircraft components. The report provides an excellent run down of the corrosion handling and treatment facilities at each of the NARF installations. It also discusses the variation of preferred corrosion treatment procedures among the NARFS where alternate methods are available in handling corrosion problems. Local engineering and local process specifications (LES & LPS's) are used to define the procedures at the local levels. The report makes no mention or reference to the handling of corrosion in ground support equipment.

5.4. Literature and reports reviewed, together with contacts with personnel, all relating to corrosion in ground support equipment, indicated little factual data of the extent and scope of GSE corrosion. In order to identify, list quantities and state manhours required to restore corroded areas and correct malfunctions attributed to corrosion, a corrosion survey of the 3M GSE Data Bank Inventory was undertaken.

5.4.1. An arbitrarily selected two year period was searched for all entries relating to corrosion from Malfunction Description Codes, reference (7), and Support Action Code, also reference (7). These codes searched are:

Malfunction Description Code

117	Deteriorated
170	Corroded

Support Action Code

040	Corrosion Control

5.4.2. The data search of over 600 categories of ground support equipment for corrosion time charges under the above codes over the two year period produced nine volumes of data, 500 pages per volume. This data represented full span organizational, intermediate and depot maintenance reporting. In order to conduct the survey within the scope allowed by allocated funding, it was decided to list only those activities at all carrier and station sites which had listed 250 or more corrosion maintenance manhours in a given category under above code numbers during the two year period of the data search. Under this manhour limitation, a total of approximately 330,000 maintenance manhours were recorded for the two year period which, when equated to an E-4 pay scale, represents approximately $1,130,000. The total reported cost is probably near $1,500,000 because of the

arbitrary exclusion of less than 250 hours reported and because the somewhat subjective nature of corrosion malfunctioning almost encourages the noncarding (MRC - Maintenance Requirement Card) of a trouble condition.

5.4.3. Nearly one hundred of the total 600 categories searched fall within the 250 hour limitation as reported by 286 station or carrier activities. The average per unit hours charged varies from 1697.5 hours for a CVA Turbo-Jet Engine Test Facility (GGBE) on USS Forrestal to as little as 3 hours for an Aircraft Universal Tow Bar (GMBC) at AIMD, Miramar. See reference (3).

5.4.4. A comparison of corrosion maintenance of Navy GSE to Navy aircraft at the organizational level is in the order of 1 to 15 based on the hours charged during FY73. This seems to be representative based on allotted manpower and the quantities of corrosion control materials and equipment used.

5.4.5. How extensive must corrosion be to be considered corrosion? The disparity between manhours logged for identical GSE between different sites indicates very different interpretations to this question. Objectively, the 3M data search is somewhat sketchy in that it only represents a count of so-called corrosion situations. What was corroded; why was it considered as being corroded; whether the corrosion actually degraded the performance of the equipment or whether it was considered corroded simply because "--it didn't look good"; - none of these are established.

5.4.6. Decision making as regards corrosion remains very much in the category of personal judgement and of little basis in fact. Considering the 3M data summarized in reference (3) as average manhours expended per unit of equipment over the two-year search period, most of the data appears insignificant. The data doesn't support the fact that GSE on carriers generally requires extensive corrosion maintenance.

5.4.6.1. The data on the NC-2A (FSN 871-9292) mobile electric power plant, for example, for seven carriers reporting, records an average of less than one hour per week for corrosion maintenance for the two-year check period.

5.4.6.2. Typically the manhours reported for the two TA-75 tow tractors (Northwestern and United manufacture) would seem impressive until it is realized that there were approximately 735 Northwestern units in service during the two-year study time and about 630 United units. Assuming the same corrosive rate applicable to all units, this sifts down to about 12 corrosion maintenance manhours per year per Northwestern tractor and about 10 hours for the United unit; both insignificant quantities, yet reflecting actual data reporting.

5.4.6.3. The jet engine test stands/facilities, starting with Category GGBE and following, appear to exhibit a logical credence in their corrosion manhours reported. These units would be particularly susceptible to the combination of salt air/moisture, jet engine exhaust gases and carrier stack gases. Based on the stands reported, approximately 50 minutes each day was expended in corrosion control over the

two-year survey period, a time period adjudged to be reasonable. Very little other data seems to be as reasonable.

5.4.6.4. The corrosion maintenance pattern must be improved and made more effective for the broad range of GSE from the design stage through and including the operational unit in the field. A part of this program must include a better way of reporting the corrosion picture for GSE in the 3M Data Bank.

5.4.7. The open-skies storage and usage situation was emphasized by many of the knowledgeable people interviewed as probably the principal contributor to the total corrosion condition. In reviewing the manhour quantities from the 3M data search for many of the GSE units, along with their probable usage pattern, this contention would appear to have some basis in fact. Because weather is so closely related to the rate of corrosion, it must be a consideration in any corrosion control program, particularly so because, as for aircraft, open-skies storage of GSE is an accepted and common practice. The attempt to compare for correlation the temperature, humidity and precipitation environment of the various sites with the maintenance man-hours reported for the various GSE equipments provided insufficient data to establish any specific patterns. Any weather influence is difficult to discern in the 3M data as now presented, even assuming that sites in and near the Tropic Zone should be reporting more corrosion maintenance manhours than sites in the Temperate Zone see reference (3). Tests have proven that the corrosion rates of structural steel in tropical atmospheres are about twice as high as the rates in temperate atmospheres (8). This higher tropical corrosion rate is attributed to the much higher relative humidity coupled with the higher average temperature. The 3M data does not substantiate these facts.

5.5. Variations in the environment effected by changing weather patterns are a primary consideration in the understanding of the corrosion process. Seawater, the most abundant naturally occurring electrolyte, is a major factor in the cause of corrosion of equipment for shipboard use and must be considered on NAS/MCAS sites adjacent to coastal waters. Most of our common metals and alloys of construction are attacked by seawater or mist-laden sea air. Since the behavior of materials may vary widely, depending on the exposure conditions, their performance is commonly discussed according to the specific environmental zone involved.

5.5.1. In the atmosphere, the intensity of the attack is influenced greatly by the amount of salt particles or mist which collects on the metal surface. Salt deposition varies with wind and wave conditions, height above the sea, exposure, etc. Since sea salts, especially the calcium and magnesium chlorides, are hygroscopic, there is a tendency to form a liquid film on the metal surface. This is particularly true where the dewpoint is reached during daily or seasonal weather changes. Typically, the value drops off rapidly, decreasing to a negligible amount about 1 mile inland, except during violent wind storms. In some areas, however, measurable salt may be found well inland.

5.5.2. Another factor that affects corrosion behavior is solar radiation. This may stimulate photosensitive corrosion reactions on metals like copper or iron and biological activity such as fungi, which help trap corrosive moisture and dust. Coral dust, combined with sea salt, is particularly corrosive at tropical sites.

5.5.3. The amount of rain, and the distribution during a given time period, affects the corrosion rate in marine atmospheres. Frequent rain may tend to reduce the attack by rinsing off any salt residue. At NAS Widbey Island, Oak Harbour, Washington, the relatively slight degree of corrosion of GSE at the station is attributed to the almost daily rinsing of any accumulated corrosive deposits from the sea atmosphere by the heavy rainfall experienced. In some cases, corrosion on the sheltered side may be worse than that on the exposed side, since dust and airborne sea salt contamination is not washed off.

5.5.4. Fungi and molds may deposit on the metal and increase corrosivity mainly by holding moisture to the surface.

5.5.5. In general, the tropical marine environments are considered more corrosive than artic marine environments, with temperate environments somewhere in between. Temperature alone, of course, is not the entire explanation for the observed differences, since the other factors involved in corrosion also vary with geographical location.

5.5.6. Sheltered steel surfaces may deteriorate more rapidly than those boldly exposed. Top surfaces may be washed free of salt by rain as experienced at NAS Widbey Island. Coral dust combined with salt seems to be particularly corrosive to steel equipment. NAS, Key West, Florida, with such an environment, has a high incidence of corrosion of GSE. Corrosion usually decreases rapidly as one goes inland.

5.5.7. The most common forms of corrosion for environments are galvanic corrosion, pitting, and crevice attack. Sand or dust erosion by wind action can augment corrosion in a marine atmosphere. In the atmosphere, galvanic-couple corrosion is confined to a short distance, usually a fraction of an inch, from the joint between the two metals. To control or prevent the accelerated attack involved in a galvanic couple, certain principles should be observed. First, the possibility of breaking the electrical circuit by providing an insulating barrier at the junction of the two metals should be considered. Second, if dependable isolation is not feasible, the cathodic member of the couple should be covered with a nonconducting protective coating. By reducing this area, or eliminating the cathode entirely, corrosion is correspondingly controlled in a safe manner. Under no circumstances should only the anode be painted. Any defect in the coating then will result in the entire cathodic area being coupled to a small area of anode material, and extremely high rates of penetration can be expected. Elimination of the bimetallic couples is a necessary design requirement, as well as a maintenance objective for all GSE.

5.5.8. Corrosion that develops in highly localized areas on a metal surface, where the remaining metal surface often is not attacked to any great extent, is referred to as pitting. Pitting on metals exposed to the atmosphere may be initiated by discrete salt particles or atmospheric contaminants. Surface features or metallurgical factors, such as inclusions, breaks in the protective film, segregation, and surface defects also may be involved in the initiation of pitting. Typical of such attack on GSE is the pitting of the chrome plated piston rod from a cylinder of an Aero 33-D Bomb Truck, figure 5-44.

5.5.9. Plain-carbon steel is the most important metal used in GSE and has been widely used for many years in marine construction. More recently, low-alloy steels of higher strength have been finding increasing application. Related ferrous materials such as cast irons, wrought iron, and ingot iron are sometimes used in special applications. Steels are selected for GSE application because of such factors as availability, cost, ease of fabrication, design experience, and physical and mechanical properties.

5.5.10. The behavior of steel and other ferrous materials tends to show striking differences in the various exposure zones. Thus, one cannot apply the results from an atmospheric exposure to an application involving immersed conditions. Mild steel corrodes in a marine atmosphere at rates ranging from 1 to 30 mpy (9). Some of this wide variation can be ascribed to factors in the environment, some to variations in certain residual elements in the steel, and some to the surface condition of the steel as originally exposed.

5.5.11. The first and most important factor influencing steel's performance in a marine atmosphere is the type of exposure. Whenever the prevailing wind and surf combine to cause large amounts of spray to be entrained and transported to the metal surface, high corrosion rates are normally observed. The rate of attack also may be affected by rainfall, humidity, temperature, solar radiation, dust, fungi, bird droppings, etc. Tropical marine environments usually are more severe than those in the temperate zone. The amount of sea salt deposited on a surface decreases rapidly with increasing distance inland. Detectable amounts have been observed from 1 to 10 miles inland. Many NAS sites fall within this zone along both East and West coasts.

5.5.12. Another factor affecting the steel's performance in the marine atmosphere is the condition of the surface as exposed. For example, when hot-rolled steel is used for construction, the mill scale is sometimes left on. The rate of penetration, based on weight loss, and the depth of pitting are greater for a mill-scaled surface than for, say, a pickled surface. This point is illustrated by the results of 8 years' exposure of steel panels at Cristobal, Panama Canal Zone (see Figure 5-1(10)). When the surface is wet with salt spray, the mill scale will serve as a relatively large cathode to the small anodes formed at breaks in the scale, and this will result in intense local attack.

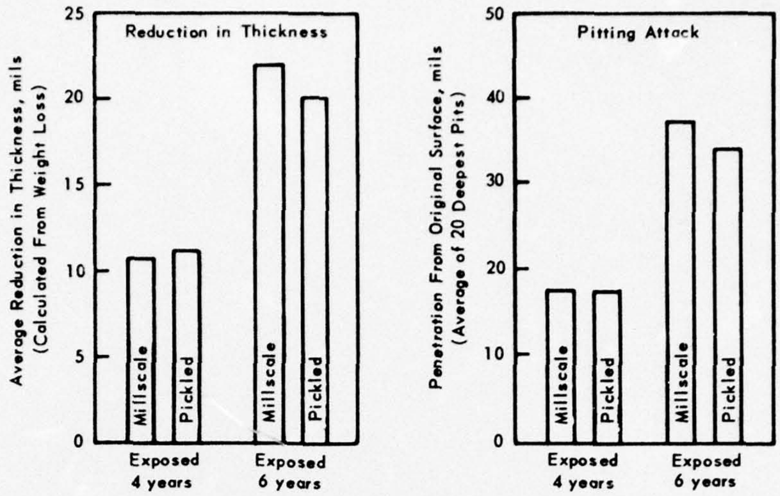

Figure 5-1. Comparison of Effects of Mill Scale and Pickled Subsurfaces on the Corrosion Resistance of Unalloyed Low-Carbon Steel Exposed to the Tropical Marine Atmosphere at Cristobal, Canal Zone (10).

5.5.13. Wrought Iron. As made in this country in recent years, wrought iron is essentially a dead mild steel to which an oxide-silicate slag has been added, while still molten. As is the case with carbon steel, unprotected wrought iron is rapidly attacked by exposure to marine atmospheres. A comparison of the behavior of wrought iron and steel is shown in *Figure 5-2* for the first 8 years of the 16-year Navy exposure program at Cristobal, Canal Zone (10). Carbon-steel behavior at the 800-foot lot, Kure Beach, N.C., is also shown for comparison. It is to be noted that the rate of penetration for steel and wrought iron after 8 years' exposure is quite similar. Both materials showed considerable pitting. The environments of these two locations are typical of many Navy sites where GSE is used and stored.

5.5.14. Low-alloy high-strength steels contain small amounts of such elements as copper, chromium, nickel, molybdenum, silicon, and manganese to provide added strength to the carbon-steel base. Low-alloy steels are not sold on the basis of analysis but on the basis of their strength. The total of the added elements is usually around 2 to 3 percent. Most of the low-alloy steels are outstandingly resistant, as compared with plain, low-carbon steel, when exposed to the atmosphere. This is especially true for industrial sites but there also is considerable advantage in their use at marine locations. The low-alloy steels show greatly improved resistance to marine atmospheres, as a result of the development of a fine-grained tightly adherent rust coat. The life of a low-alloy steel structural part may be approximately five times as long as that of a similar carbon steel part. Investigation for cost effectiveness of low-alloy steels in GSE may be justified by this additional life expectancy. Also a good marine coating, will last longer when applied to a properly prepared low-alloy steel surface than when applied to a carbon steel substrate.

5.5.14.1. The first indication that composition affected corrosion behavior was the observation some 55 years ago that copper-bearing steels showed improved endurance

Eight-Year Corrosion Behavior, mils

Metal	W.I.	Low-C Steel	Cu Steel	Low-Alloy Steel
Avg red in thickness	22.1	20.4	17.6	9.0 to 10.1
Avg of deepest 20 pits	29	34	32	12 to 18
Deepest pit	61(P)	67*	66(P)	17 to 63(P)

P = perforated * probably perforated

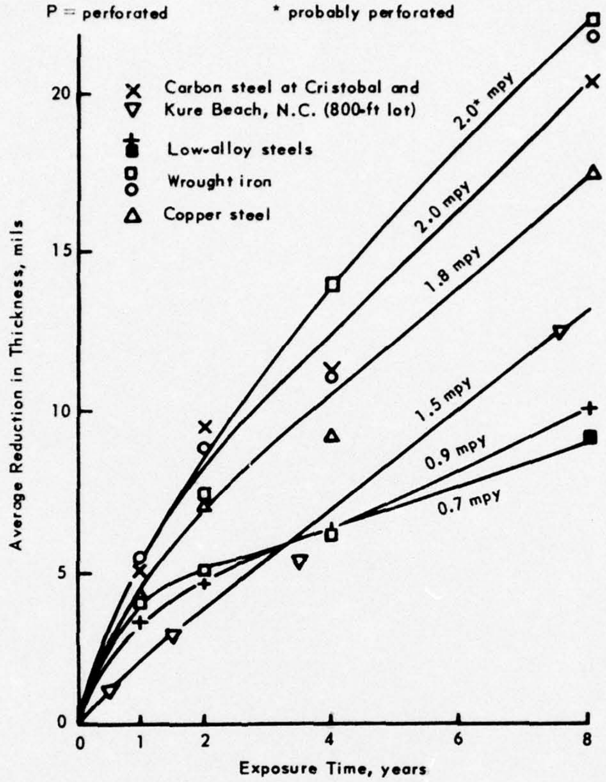

Figure 5-2. Corrosion Results for Wrought Iron and Steels after Eight Year's Atmospheric Exposure at Cristobal, Canal Zone (10).

in industrial atmospheres. Later it was found that the copper-bearing steels also performed better than plain-carbon steel at ocean sites. Among others, the Navy and the ASTM have provided information on the excellent behavior of copper-bearing and low-alloy steels at marine sites. In the Navy program, after an 8-year exposure at Cristobal, Panama Canal Zone (10), penetration rate calculated from weight loss, for low-alloy steels ranged from 0.7 to 0.9 mpy, as illustrated in Figure 5-2. At the 800-foot lot at Kure Beach, N.C., the 15.5 year results indicated a rate of 0.3 mpy or less for low-alloy steels. In general, a total alloy content of 2.0 percent for these types of steels seems to provide the maximum return in performance.

5.5.14.2. Tight Rust Formation. The benefit derived from the addition of copper to steel exposed to an industrial atmosphere has been ascribed to the relatively insoluble basic sulfates, from the SO_2 in the polluted air, which slowly develop in the rust

film. Additions of nickel, chromium, and - to a lesser degree - silicon and phosphorus also were found to promote relatively insoluble corrosion products (9). The film of electrolyte on a panel at a marine atmospheric site is high in chlorides, as one would expect, and lower in sulfate. Since basic chlorides are not so insoluble as the basic sulfates predominating in the hydrate iron oxide film developed at industrial sites, one would not expect the film developed at a marine site to be as protective. This is found to be the case. The manner in which protective rust coats do form under marine conditions is less understood than that in the case of the industrial atmosphere. The formation of the rust coat is influenced by the amount of salt mist carried in by the prevailing wind, rainfall, sunshine, fungi, humidity cycle, dust, and, at some marine sites, pollution. (Occasionally, a trace of SO_2 is present in the atmosphere at the Kure Beach, N. C., lots, some 15 miles from Wilmington, the nearest city). As with carbon steel, the amount of sea salt reaching the exposed surface and retained on the surface greatly affects the rate of attack. The 80-foot lot at Kure Beach, N. C., is one of the most corrosive test sites in use for marine-atmosphere testing. Even under these severe conditions, the low-alloy steel corrodes at a lower rate than mild steel, see Figure 5-3. However, the indicated rate for the low-alloy steel at this location is sufficiently high to require protection in comparable environments for many applications.

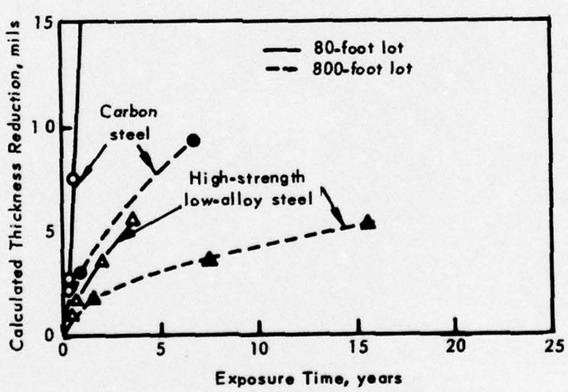

Figure 5-3. Comparison of Corrosion Results for Various Steels in Marine Atmosphere, Kure Beach, N.C. (11).

5.5.14.3. Pitting Attack. Some idea of the pitting performance of low-allow steels in a severe marine climate is provided by the results from the Canal Zone site. A few of the exposure panels were perforated after 8 years, i.e., they showed

greater than 63 mils penetration. More typically, the deepest pits ranged from 17 to 28 mils. Thus, a pitting allowance of 4 mils per year would be conservative for a low-alloy-steel structure where perforation would cause failure (10).

5.5.15. Stainless steels, as a class, find only limited application in marine environments. They perform well only in marine atmospheres where the passivity can be maintained by bold exposure of the surface.

5.5.15.1. In general, the three grades of stainless steels, namely, martensitic, ferritic, and austenitic, have good to excellent resistance in marine atmospheres. The austenitic grades are preferred because of their greater resistance to staining. At first, a superficial yellow stain develops, but after a few years it may become reddish in color. It can be readily removed with metal polish.

5.5.15.2. Corrosion rates for the austenitic grades are low, and pitting or crevice attack is not normally experienced in the atmosphere if simple precautions are taken.

5.5.15.3. A Type 304 panel exposed at the 800-foot lot at Kure Beach, N.C., corroded at a rate of less than 0.1 mpy. At the 80-foot lot, Type 304 panels showed somewhat more staining but negligible attack after 11 years. Type 316 panels have a higher order of resistance than Type 304 under the same exposure conditions. The results of 8-year atmospheric exposures at Cristobal, Canal Zone, for these stainless steels are compared in Figure 5-4. Note that the austenitic grades were free from pitting or weight loss (12).

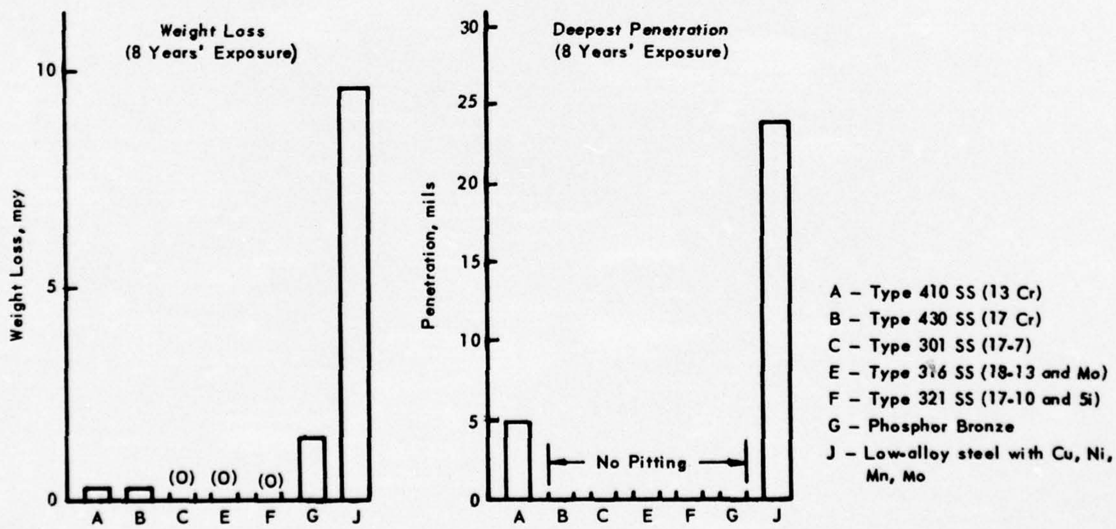

Figure 5-4. Comparison of Corrosion Damage of Stainless Steel, Phosphor Bronze, and Low-Alloy Structural Steel in Tropical Marine Atmosphere at Cristobal, Canal Zone (12).

5.5.15.4. The martensitic stainless steels, as typified by Type 410, may experience rust after only a few months of exposure to the marine atmosphere. Type 410 has the minimum chromium content (12 percent) required for passivity, and local breakdown may be experienced. The deepest pit on a panel exposed at Cristobal for 8 years was 5 mils (see Figure 5-4);however, the weight-loss penetration was only 0.007 mpy.

5.5.15.5. Type 430, a ferritic grade stainless steel, becomes rusted over part of its surface after a year or so. The higher chromium content (17 percent) as compared with Type 410, promotes greater resistance to pitting. The general corrosion attack at marine sites, such as at Cristobal, is barely measurable on a weight-loss basis (12).

5.5.16. Nickel. Nickel corrodes at rates of the order of 0.01 mpy or less in the marine atmosphere (13). Its main useful field of application is not as a structural metal but as a coating, such as an electroplate. Specially tailored combinations of electrodeposits of copper, nickel, and chromium provide years of economical protection to steel or zinc-base die castings exposed to marine atmospheres. Such coatings are used on component parts of GSE such as instrument cases and bezels, control handles, switch levers and similar exposed parts subject to frequent handling.

5.5.16.1. Nickel panels have been exposed to the marine atmosphere to establish rates of penetration. At the 80-foot lot in Kure Beach, N.C., the weight-loss penetration for a 7-year exposure was 0.0095 mpy and the deepest pit was 1.4 mils (13). At Cristobal, Canal Zone, the rate for 16 years' exposure was 0.0075 mpy with negligible pitting (14). These examples with nickel sheet confirm the good experience with nickel coatings. The resistance of nickel to marine atmospheres is of the same order as that found for rural atmospheres (15). Compare, for example, the results of ASTM exposures, as reported by Copson (16) in Table I. Note also the effect on nickel when the marine atmosphere becomes polluted, as at Sandy Hook. The corrosion rate at this marine site near New York is an order of magnitude higher than that at unpolluted marine sites and reflects the presence of sulfur products in the atmosphere.

5.5.16.2. The nickel-copper alloys, as typified by Monel-400, have good resistance to marine atmospheres, although they will tarnish and show weathering. For example, after 7 years at Kure Beach, N.C., a light green patina, darker at the edges of the panel, had developed on Monel-400 (13). These specimens show low rates of corrosion; e.g., 0.014 mpy after 7 years at Kure Beach (13) and after 16 years at Cristobal (14). The rates at the ASTM sites shown in Table I are even lower than those mentioned above. This good behavior is borne out by experience. Monel-400 has given years of excellent service as a material of construction in marine applications. Monel-400, like stainless steels, is susceptible to oxygen-concentration-cell corrosion. Thus, crevices and other areas where sea-salt solutions may be trapped and set up local cells should be avoided in designing.

Table I - Atmospheric Corrosion Behavior of Nickel and Monel - 400 After 10 and 20 Years in the Marine Atmosphere (16).

Metal	Site	Corrosion Rate, mpy 10 Years	20 Years	Exposure
Nickel	Key West, Florida	.0050	.0041	Marine
	LaJolla, California	.0047	.0056	Marine
	State College, Pa.	.0066	.0085	Rural
	Sandy Hook, N. J.	.0313	--	Polluted marine
Monel-400	Key West, Florida	.0065	.0045	Marine
	LaJolla, California	.0077	.0064	Marine
	State College, Pa.	.0050	.0067	Rural
	Sandy Hook, N. J.	.0266	--	Polluted marine

5.5.17. Aluminum alloys are finding ever-increasing application in marine environments. For marine structures, the 5086-H32 or -H34 alloy has been widely used. It has excellent resistance to corrosion, is weldable, and can be strain hardened to provide moderately high strength. Other 5000 series alloys which also find use are 5083 and 5456. For applications requiring higher strength, the corrosion-resistant 6061-T6 has often been selected particularly as a structural member or closure panel for GSE. The welding of 6061 causes loss in ductility, but the alloy can be heat treated to provide higher strength than is available with 5086-H32. Alloys with relatively poor corrosion performance in marine environments include the 7000 series (zinc and Magnesium), the 2000 series (copper), and the 4000 series (silicon). Since the corrosion resistance depends on the maintenance of the passive oxide film, aluminum and its alloys generally are most resistant in those marine environments where the metal surface is freely exposed to well-aerated seawater or to the atmosphere. Failures by local attack such as by pitting, crevice corrosion or exfoliation, or stress cracking are characteristic of many alloys, particularly the high-strength alloys.

5.5.17.1. Alloys which exhibit good behavior when exposed to marine atmospheres include 1100, 3003, 3004, 5052, 5056, 5083, 5085, 5154, 5456, and 6061. When aluminum alloys are exposed to an aggressive marine location, the initial corrosion rate, based on weight loss, may be as high as 4 mpy. After a year or so, the rate usually tapers off to a low value approaching 0.1 mpy.

5.5.17.2. The good performance of Alloy 1100 is illustrated in Table II which summarizes 10- and 16-year exposure data from widely different marine sites. Even at LaJolla, California, where the mist-laden air and high wind combine to bring a heavy deposit of salt to the metal surface, the total loss in thickness in 10 years was only 0.56 mil.

Table II - Ten-Year Weathering Results for 1100 Aluminum in Marine Atmospheres (17).

(Panels 9 x 12 x 0.035 Inch)

Site	Corrosion Rate[a] mpy	Tensile Loss percent
Sandy Hook, New Jersey	0.002	3.1
Key West, Florida	0.004	1.7
LaJolla, California	0.028	14.1
Cristobal, Canal Zone[b]	0.007	-

(a) Calculated from weight loss
(b) Sixteen-year exposure (18)

5.5.17.3. For atmospheric service, the aluminum-magnesium alloys, e.g., 5050, 5086, and 5154, are considered among the most suitable. Alloy 6061 is also highly satisfactory. All of these aluminum alloys are used in GSE although not nearly to the extent that carbon steel is employed.

5.5.17.4. Because of its resistance to attack, aluminum is sometimes exposed without added surface protection. However, anodizing may be used to enhance the resistance of the natural oxide film. Even better results are achieved with a protective coating. Paint adheres well to aluminum and a suitable marine formulation will provide long-lasting additional protection. Marine experience with aluminum structures has shown that repainting is required only about half as often as would be the case for the same marine paint system applied to steel construction. The normal surface treatment for GSE includes surface preparation, a primer, and an enamel finish coat.

5.5.17.5. Pitting, which has its own unique type of attack pattern on aluminum alloys, frequently is found in GSE where surfaces are left exposed or where the surface coating has been broken. Since many aluminum alloys tend to pit in marine atmospheres, the extent measured at a number of sites for four different aluminum alloys by AILOK, reference (19), are presented in Figure 5-5. In this comparison, Alloy 6061 showed the best performance with maximum pitting ranging from 3 to 7 mils. Since the rate of pitting tends to taper off with time, designers can allow for it in applications where penetration would mean failure, e.g., tanks. In marine service, pits are observed both on the skyward and groundward faces of exposed surfaces. Evidence of this type corrosion attack was found in GSE at NAS/MCAS sites on both the East and West Coasts.

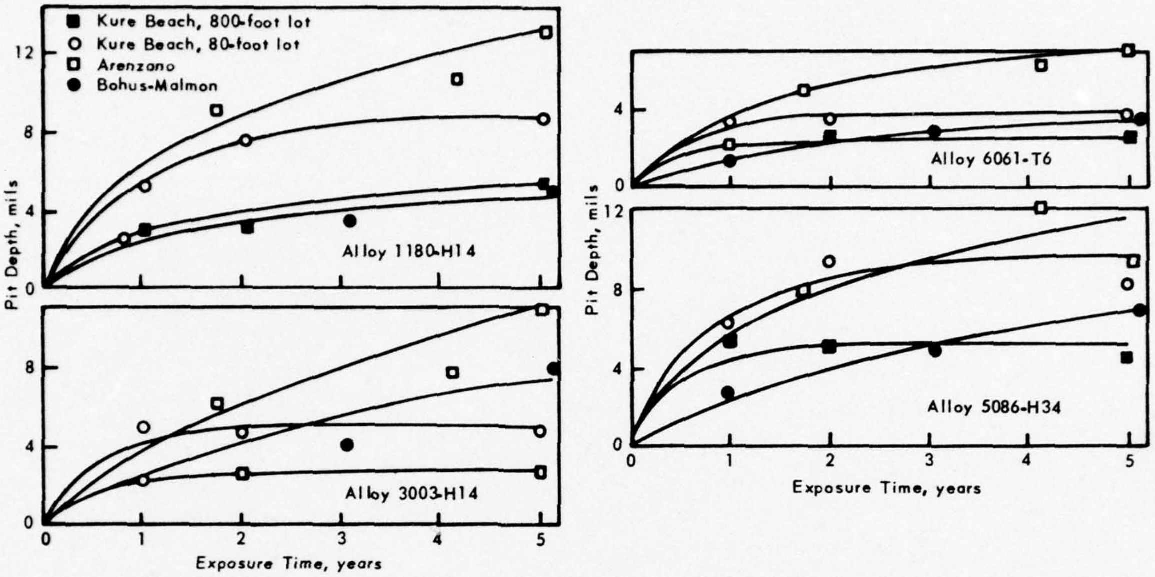

Figure 5-5. Maximum Measured Pit Depths for Aluminum Alloys in Selected Marine Atmospheres (19).

5.5.17.6. Exfoliation is a form of intergranular corrosion. It manifests itself by lifting up the surface grains of a metal by the force of expanding corrosion products occurring at the grain boundaries just below the surface. It is visible evidence of intergranular corrosion and is most often seen on extruded sections where grain thickness is less than in rolled forms. Intergranular corrosion is an attack on the grain boundaries of a metal or alloy. A highly magnified cross section of any commercial alloy will show its granular structure. This structure consists of quantities of individual grains, and each of these tiny grains has a clearly defined boundary which chemically differs from the metal within the grain center. Frequently the grain boundaries are anodic to the main body of the grain, and when the grain boundaries are in this condition and in contact with an electrolyte, a rapid selective corrosion of the grain boundaries occurs. An example of intergranular or grain boundary corrosion is that which occurs when aluminum alloys are in contact with steel in the presence of an electrolyte. The aluminum alloy grain boundaries are anodic to both the aluminum alloy grain and the steel. Intergranular corrosion of the aluminum alloy occurs. An example of exfoliation as experienced on GSE is shown in Figure 5-6 picturing the rail of a T-58 Engine Transport Trailer at AIMD, North Island, San Diego. Evidence of pitting may also be seen in this figure. Figure 5-7 shows extensive exfoliation of structural members from an E2A Aircraft Lifting Sling from the NARF, North Island, San Diego, which had to be "surveyed" because of corrosion. This is the first item of GSE encountered on Both East and West Coast NAS/MCAS

sites investigated for corrosion problems that had to be replaced, "surveyed", strictly because of corrosion.

5.6. Because the survey of corrosion control related entries for GSE in the 3M Data Bank failed to provide detailed specifics of corrosion problems, due to the general nature of its reporting, an on-site survey was made of NAS/MCAS sites, East and West Coasts and from the Fleet. These necessary on-site specifics have been acquired in the form of (1) a photographic record, (2) from interviews with cognizant GSE maintenance/corrosion control personnel and (3) by observation of available corrosion control facilities, equipment and manpower.

5.6.1. The field survey of GSE corrosion conditions existing at NAS, MCAS, NARF and FLEET produced approximately seven hundred fifty photographs, between East and West Coast facilities, of various GSE corrosion. The field survey with its attendant photo record of conditions encountered enabled identification of GSE corrosion problems. Also, interviews with responsible corrosion control personnel at all the various facilities provided necessary data regarding corrosion removal and control techniques employed at each site as well as personnel attitudes and expressed needs.

5.6.2. Specific corrosion problems identified by this photo record will be discussed in succeeding paragraphs. Because of the volume of photos from each site, a key was devised to apply to each photo in order to establish a uniform system of photo evaluation and also to indicate trends, if possible, that could be attributed to the varying environmental conditions encountered. The key, see Figure 5-8, breaks down the corrosion incidents encountered and photographed into seventeen categories for purposes of comparison. These categories evolved with the analysis of corrosion problems chronicled in the photographs from one site and were subsequently applied to photos from all other sites surveyed.

5.6.2.1. Delamination is evident on the enclosure door of a type C-1A Propeller Dolly from NAS Jacksonville, Figure 5-9. This corrosion is identified by Key No. 1 and shows delamination caused by an advanced corrosive state in which the steel plate in the presence of salt laden water has formed a build up of iron oxide.

5.6.2.2. In some cases with GSE, at time of repainting, corrosion removal is not complete with the result that because of inadequate preparation, the paint coating is merely cosmetic allowing corrosion to continue beneath the paint ultimately causing delamination. This type of corrosion is identified by Key No. 2 and is typical of delamination caused by expanding iron oxide under a cosmetic overcoating where inadequate preparation has allowed the corrosion to continue, Figure 5-10.

5.6.2.3. Water entrapment in GSE is frequently the initiator of breakdown of surface coatings with subsequent progressive corrosion. This entrapment is found in places where water can form pools; where drains are plugged or don't exist; and

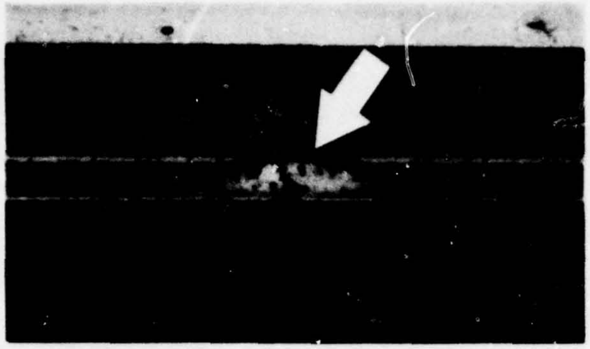

Figure 5-6. T-58 Engine Transport Trailer Exfoliation

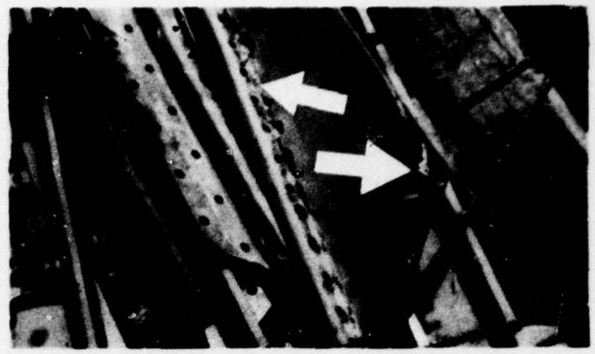

Figure 5-7. E2A Aircraft Lifting Sling Exfoliation

KEY NO.	CORROSION IDENTIFICATION CATEGORIES	% OF TOTAL OCCURRENCE
1	Delamination - Advanced Corrosive State	17
2	Delamination - Cosmetic Overcoating/Poor Preparation	8
3	H_2O Entrapment - Pool/No, or Plugged Drains/Inadequate Ventilation	7
4	H_2O Entrapment - Capillary Between Mating Surfaces	13
5	Scratches Through Coating	7
6	Impingement - People Induced	16
7	Impingement - Air Borne Particulate	2
8	Enclosure Inadequate - Size/Sealing/Vents	1
9	Closure Insecure - Negligence	1
10	Inaccessibility for Proper Surface Preparation/Coating	2
11	Acid Attack	2
12	Electroplating Too Thin	-
13	Exposed Surface Unprotected	7
14	Design Deficiency	4
15	Improper Coating Used	2
16	Weathered Surface Coating	8
17	Pitted Surface Coating	3

Figure 5-8. Corrosion Identification Key Used to Tabulate and Compare Photo Corrosion Categories

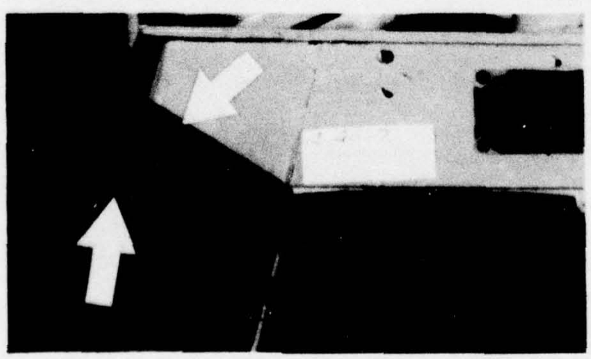

Figure 5-9. Typical Delamination - Advanced Corrosive State - Identified by Key No. 1

where inadequate ventilation retards evaporation rates. Such water traps in GSE are identified by Key No. 3 of which Figure 5-11 of an Air Compressor at Beaufort, S.C., is a classic example. Corrosion from this type of entrapment is readily prevented during equipment design by inclusion of adequate drains and enclosure ventilation provision for storage periods. Even with good ventilation, a trap capable of holding a moderate volume of water will require many days to evaporate completely. This retained water maintains conditions under which corrosion can progress. Figure 5-12, of the same C-1A Propeller Dolly shown in Figure 5-9, shows the results of a number of cycles of water entrapment and a subsequent evaporation. Sediment in the form of airborne particulate matter collects and holds water for much longer periods. Another illustration of water entrapment is shown of the swivel wheel structure of a trailer for small aircraft engines at NAS Jacksonville, Figure 5-13. Water trapped in the pan shaped structure found a break in the paint coating and the resulting corrosion progressed to cause the delamination pictured. There is undoubtedly even more severe corrosion on the underside of the pan where the swivel wheel is bolted to the structure caused by seepage through the center opening.

5.6.2.4. A second type of water entrapment is even more common than that caused by pooling. This type is caused by the capillary characteristics of water finding its way between two mating surfaces. Capillarity occurs at any unsealed joint between adjacent surfaces regardless of orientation. It is most frequently found on GSE where panels are intermittently welded or bolted to supporting structural members. An example of this capillary water entrapment from the structure of a 6000 lb. lift truck is shown in Figure 5-14. Another example illustrating capillary entrapment with its resulting corrosion is shown of the interior of an enclosure on a GPCU Utility Tractor, Ford W-30. In this a welded hat section has both flanges rusted away to a point where the channel remaining provides no support whatsoever for approximately eight inches of its length. See Figure 5-15. This unit has been deployed on a land base in Alaska and is typical of interior corrosion caused by condensation.

Piano type hinges on closure doors of GSE are often found to be a source of corrosion by capillary induced water entrapment, sometimes in the hinge itself if infrequently used, but generally under the bolted or spot welded flanges. Figure 5-16 shows the effect of water entrapment in the hinge of an access door on a GAED Mobile Motor Generator, MMG-2, Inet Sprague at Pensacola, Florida. The darkened paint area of the hinge and some of the finish of the door indicates that temporary corrosion prevention measures have been taken by coating with corrosion preventive compound MIL-C-16173 or MIL-C-81309. All of the examples shown in Figures 5-14, 5-15 and 5-16 are this type of water entrapment (key no. 4).

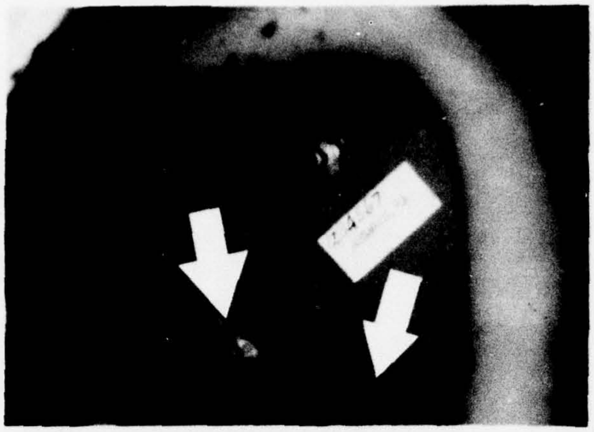

Figure 5-10. Typical Delamination - Cosmetic Overcoating/ Inadequate Preparation.

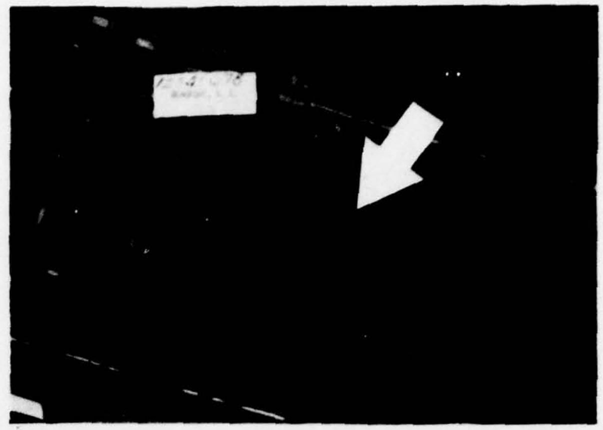

Figure 5-11. Water Entrapment - Pool Inside Loaded Compartment No Rain For 10 Days.

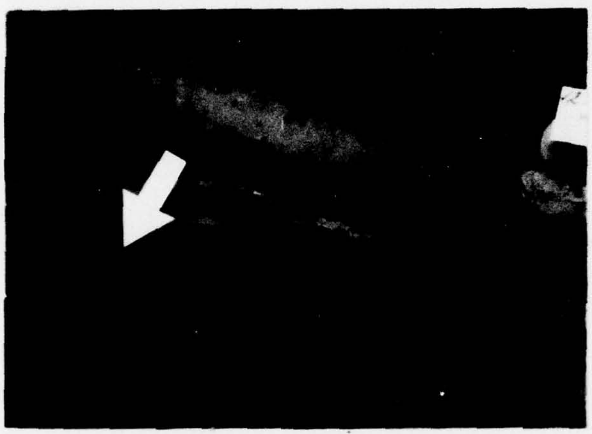

Figure 5-12. Water Entrapment - No Drain - Sediment and Corrosion Products

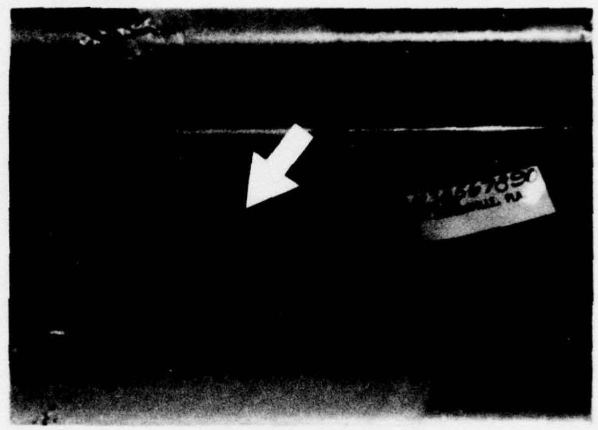

Figure 5-13. Water Entrapment Caused Corrosion and Delamination.

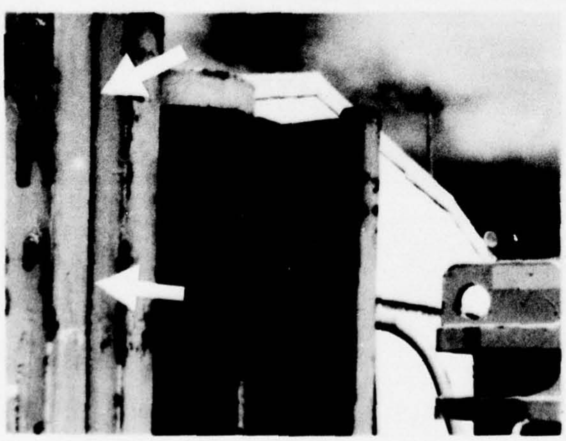

Figure 5-14. Water Entrapment Capillary Between Mating Surfaces.

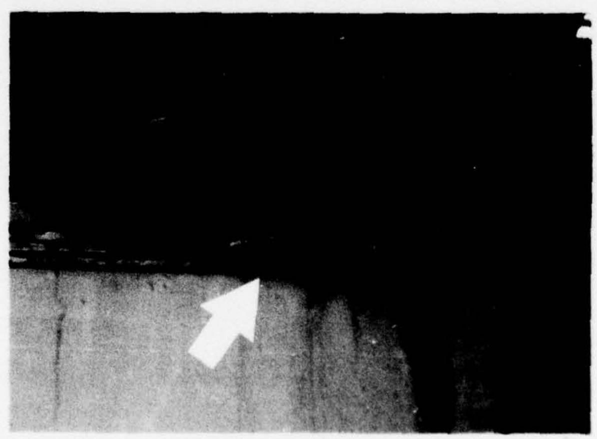

Figure 5-15. Water Entrapment Induced Corrosion.

5.6.2.5. Scratches Through Coating, Key No. 5, is primarily applicable to exterior surfaces and these are more often flat horizontal surfaces where tools and equipment can be placed. Many scratches also are found within foot and arm reach areas on GSE and around the exterior periphery where other objects make contact. As referred to in previous paragraphs any scratch through a protective coating becomes a possible source of corrosion. Therefore, a great effort has been made to provide surface coatings with high abrasion and scratch resistance. Surface strength of paints have been improved and a wide variety of very tough durable plastic coatings have been developed. Typical of the type of finish damage which has spurred development of these finishes is the top surface of a T-75A Aircraft Tow Tractor at Pensacola, Florida, shown in Figure 5-17. Evidence is clearly visible of the progressing corrosion in areas where the surface coating has been scratched down to base metal.

5.6.2.6. Another form of equipment degradation is that of impingement. For purposes of evaluation the corrosion key considers this in two categories - People induced and Airborne Particulate. Impingement - People Induced, Key No. 6, is caused by impact betwen tractors and the hitches of trailers, by thrown down cable, tools, etc., and also by some thoughtless acts of individuals as is shown by the condition of the TA-75 Aircraft Tow Tractor Air Filter in Figure 5-18. The location of this air filter directly in front of the passenger seat makes it particularly vulnerable to the tool wielding enthusiasm of young sailors. This sort of problem is most readily corrected in the design phase prior to any procurement by relocation to a less vulnerable location.

Another example of impingement is shown in Figure 5-19 of the front of a TA-75A Aircraft Tow Tractor at Beaufort, S.C. The heavy steel plate on the front of most TA-75's, after relatively short periods of use, has its paint almost all marked and scored as in this photo. The paint condition on such heavy steel plate becomes primarily cosmetic as corrosion here would not degrade the functioning of the tractor. The broken radiator grille shown is fortunately not common of most TA-75 tractors.

5.6.2.7. Impingement - Airborne Particulate, Key No. 7, is the identification term used to indicate such cases as eroded surface finish from airborne sand and such matter in the area of fenders and wheel wells of wheeled GSE. In desert areas, high winds have been known to "sand blast" vehicles down to bare metal. Fortunately most GSE is stored in paved areas where this type of impingement is minimal. Figure 5-20 shows the effects of such erosion on the paint finish of a Ford W-30 Utility Tractor at NARF, North Island, San Diego.

Another illustration of this type of impingement is shown in Figure 5-21 of an MD-3 Hough Tow Tractor, code GPCL, also from the NARF, North Island. This MD-3 wheel well shows a combination of particulate erosion and evidence of painting over an improperly prepared surface as indicated by paint delamination.

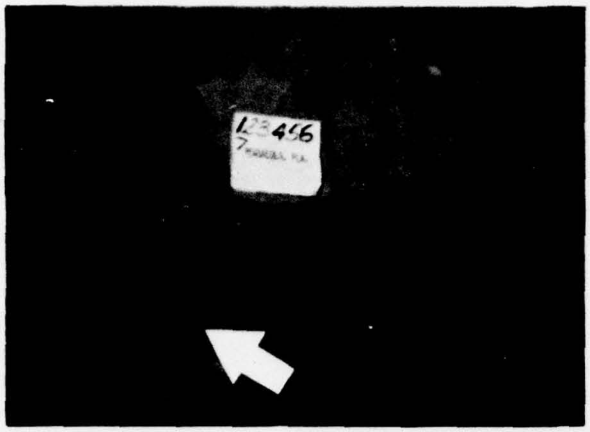

Figure 5-16. Water Entrapment - Access Door Hinge.

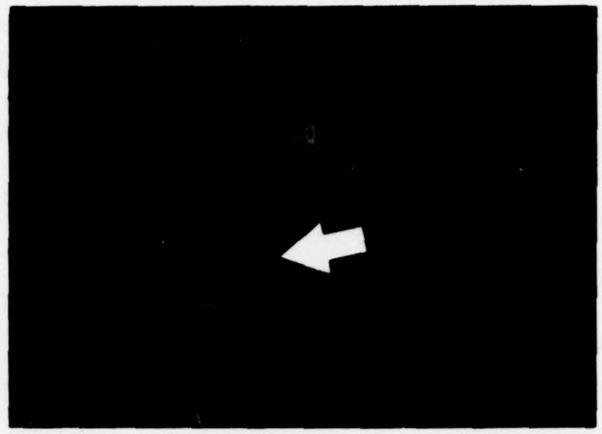

Figure 5-17. Scratches Through Coating of MIL SPEC TT-E-489 Alkyd Enamel.

Figure 5-18. Impingement - People Induced on TA-75A Tractor Air Filter.

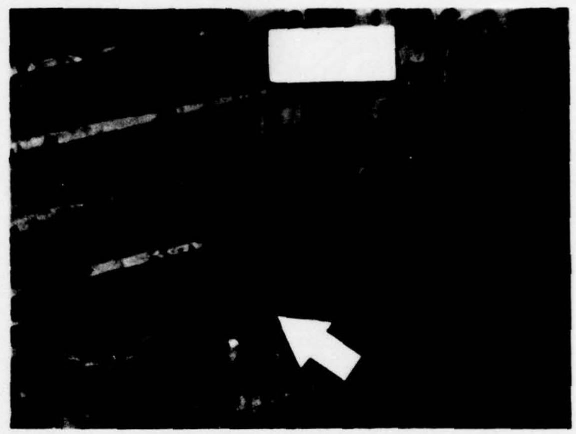

Figure 5-19. Impingement, Key No. 6, on TA-75 Aircraft Tow Tractor

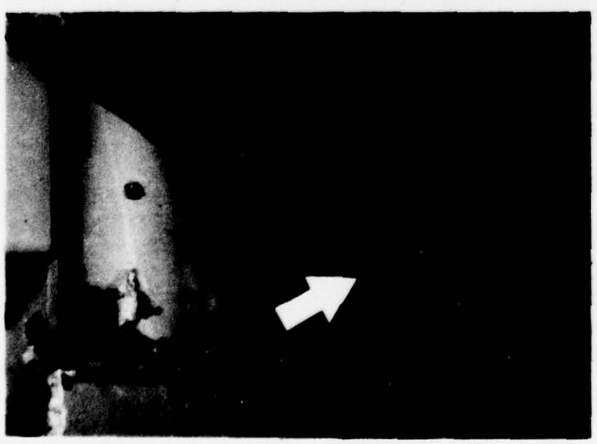

Figure 5-20. Particulate Impingement on Utility Tractor

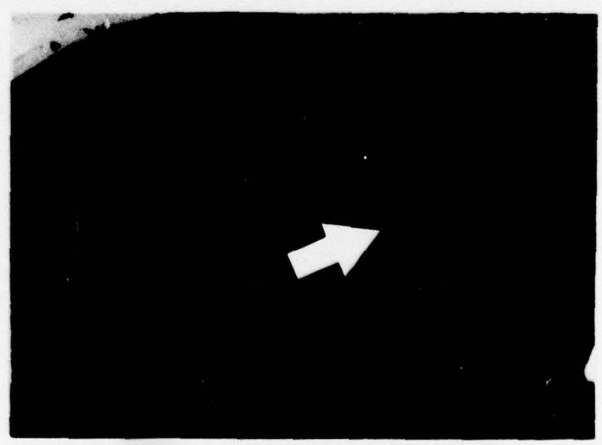

Figure 5-21. Surface Erosion in Wheel Well of MD-3 Tractor

5.6.2.8. On some GSE containing electrical and/or instrument panels, internal corrosion was found. This internal corrosion was due to deficiencies in the enclosure in some cases, and these are identified as Key No. 8, Enclosure Inadequate - Size/Sealing/Vents. Even gasketed enclosure doors admit moisture through the condensation incurred by daily outside temperature fluctuations. This may be overcome by hermetically sealing, providing sufficient ventilation to prevent the condensation or using moisture trap type vents. These options should be considered and included as selected during the design phase of a GSE item. Figure 5-22 is of an NF-2 Generator Floodlight Set, unused since recent rehabilitation when all gages were replaced and with gage cases already showing effects of condensation induced corrosion within the enclosure.

Another example of corrosion within an electrical enclosure shows a terminal strip support bracket in an NC-10B Mobile Electric Power Plant - Diesel, GAC4, Figure 5-23. Corrosion control on the exterior of MEPP's is relatively simple to accomplish; however, within an electrical enclosure, corrosion will not be touched until it must be in order to correct a malfunction or to quote one of the corrosion control chiefs, "it isn't corroded until it stops working". This type of corrosion is usually left untouched until the unit is sent into one of the NARF's for a complete rehabilitation when it is fully checked out and "zero" timed. During rehabilitation, "replacement" rather than "repair" is the general procedure and frequently the most economical for small parts corrosion.

5.6.2.9. Enclosure Insecure - Negligence, Key No. 9, is used to indicate cases where access doors have been bent to the point where they no longer close, latches are damaged or missing, hinges no longer allow full closure or where doors have rusted through or been eaten away by battery acid. Figures 5-24 through 5-30 are from sites where GSE conditions illustrate this type of enclosure damage.

5.6.2.10. GSE design in some cases builds in potential problems with future corrosion. Such a case exists where the GSE has areas that are inaccessible for proper surface preparation and coating, yet are still exposed to corrosive attack. This is identified in the Corrosion Key as No. 10. When areas are not accessible for proper surface preparation and the equipment is painted, existing progressing corrosion is merely covered over by a layer of paint thus allowing the corrosion to continue. Evidence of this may be seen in Figure 5-31 showing a TA-75 Tow Tractor that has just been painted. The area shown is inaccessible for disc sanding which is the common method of surface preparation of this NAS and is not easily hand scraped and wire brushed.

5.6.2.11. Acid attack is another category of corrosion frequently encountered in GSE. The sides and bottom of battery compartments are usually coated, however, adjacent access doors are generally heavily attacked by the acid fumes, see Figure 28. Even with acid resistant coatings and plastic battery boxes tie down devices are frequently heavily attacked as well as battery compartment access doors, see Figures 5-32, 5-33, and 5-34.

Figure 5-22. Condensation Caused Corrosion on NF-2 Instrument Case

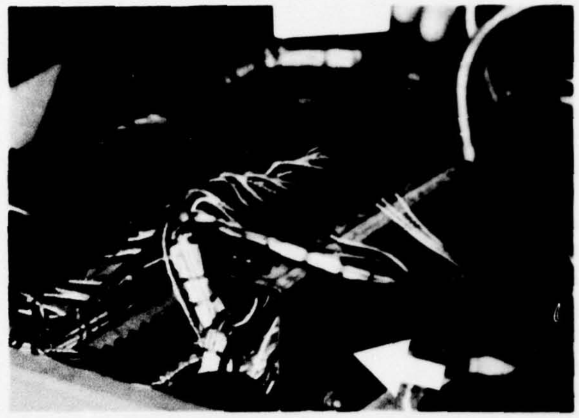

Figure 5-23. Electrical Compartment Corrosion of Terminal Strap Support Bracket

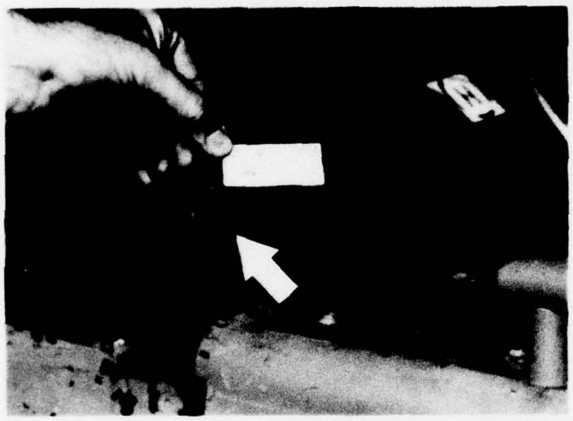

Figure 5-24. SATS Weapons Loader - Bent Top Cover

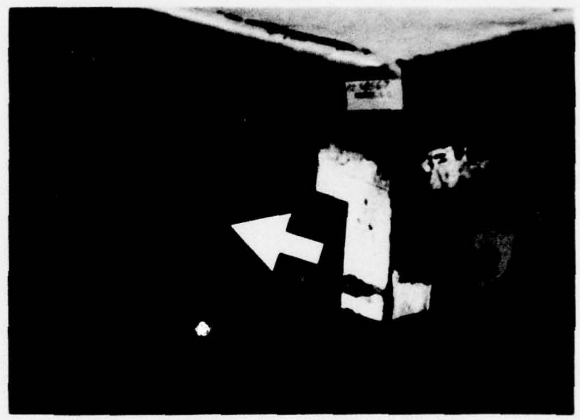

Figure 5-25. GHCH Oxygen Recharge Service Trailer - Broken Cover Latch

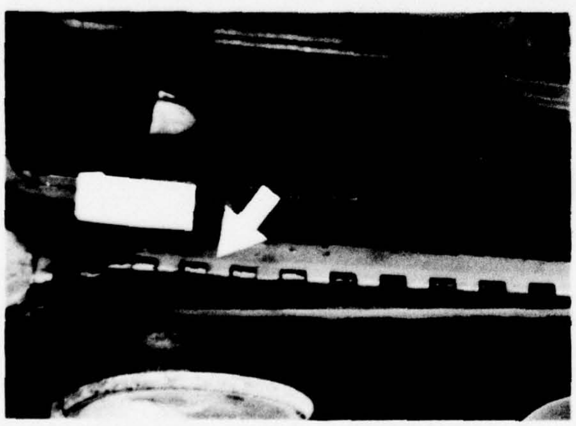

Figure 5-26. SATS Weapons Loader - Bent Hinge on Engine Compartment Cover

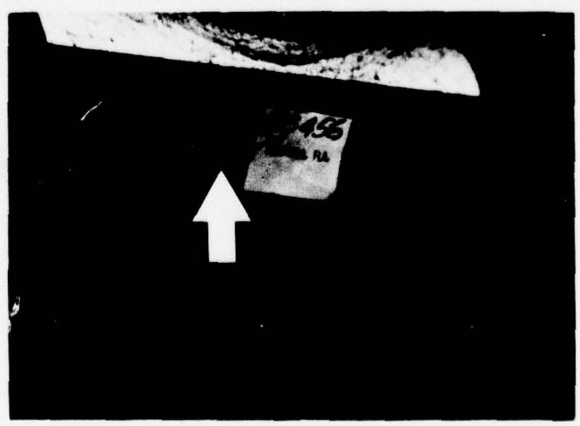

Figure 5-27. TA-75 Tow Tractor - Battery Access Door Damaged - Fasteners no Longer Engage

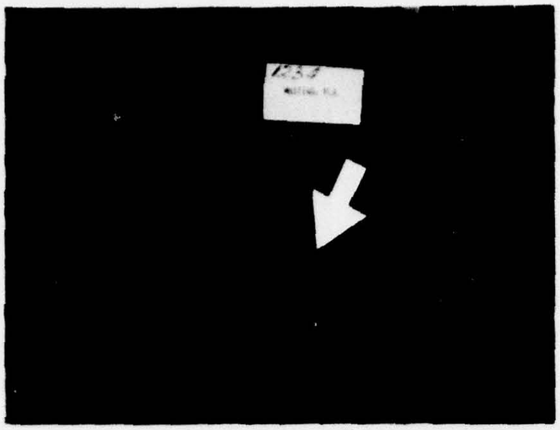

Figure 5-28. Hydraulic Test Stand - GGE3 Battery Access Door - Acid Corrosion

Figure 5-29. GFBE Air Compressor - Joy Mfg. Co. - Damaged Door Hinge

Figure 5-30. GFBE Air Compressor - Joy Mfg. Co. - Damaged Hinge Support Member

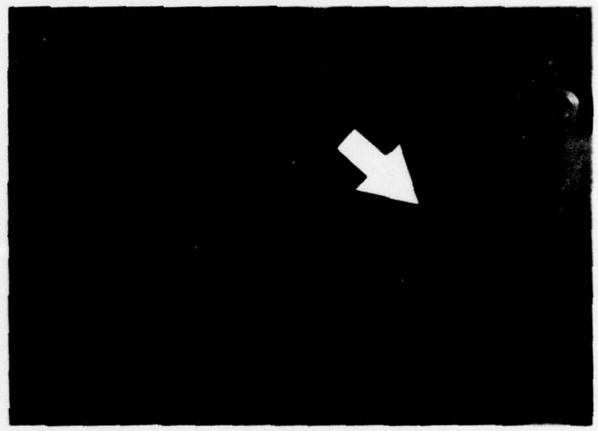

Figure 5-31. TA-75 Tow Tractor - Inaccessible Area for Proper Surface Preparation/Coating

Figure 5-32. Tow Tractor Battery Compartment - Acid Induced Corrosion

Figure 5-33. MMG-2 Inet Sprague Motor Generator - Battery Compartment Corrosion

5.6.2.12. Electroplated surfaces on instrument cases and piston rods were observed to have been heavily attacked by corrosion at many NAS sites. This type of corrosion is identified as Electroplating Too Thin, Key No. 12. Examples of this corrosive attack are shown in Figure 5-35 of an NC-8A Mobile Electric Power Plant GAC6 by Consolidated Diesel and in Figure 5-36 of an ETU-8/E Engine Removal and Positioning Trailer Model 4000A, GMBB by Air Logistics.

5.6.2.13. Figure 5-37 of a worm screw on an Aero 51-B Munitions Handling Trailer is characteristic of many such examples found of Key No. 13 - Exposed Surface Unprotected. Most exposed machine surfaces if not lubricated or otherwise protected on a regular periodic basis during storage will within a relatively short time corrode to a similar state as Figure 5-37.

5.6.2.14. Design deficiencies make themselves apparent during use of GSE which if considered during the design phase could be eliminated as future sources of maintenance problems. Many examples of this Corrosion Key category, Key No. 14 - Design Deficiency, may be found in the hundreds of photos compiled of GSE corrosion. Figure 5-38 of the seat cushion from an NC-12 Mobile Electric Power Plant is typical of nearly all self propelled GSE - some seats have covering and cushioning completely gone. Figure 5-39 of the port side of the engine compartment of a SATS Weapons Loader shows corrosion of the shroud caused by heat from the muffler. As space in this unit is at a premium the use of high temperature enamel in this area would prevent such rapid corrosion. Figure 5-40 of the Air Start Unit from an MD-3 Tow Tractor removed from shipboard shows a break in the frame. This unit is cantilevered from the back of the MD-3 and is subject to tension and vibration.

5.6.2.15. Corroded fittings from a Breathing Oxygen Charging Cart, Figure 5-41, from a shipboard unit illustrate Improper Coating - Key No. 15. Some of the fittings require periodic replacement because of corrosion while adjacent fittings still provide satisfactory service. This complaint was voiced by a number of AMD personnel interviewed aboard USS Independence.

5.6.2.16. The shipboard deployed MD-3 Aircraft Tow Tractor, Figure 5-42, exemplifies the type corrosion identified as Weathered Surface Coating, Key No. 16. Some of the weathering is caused by various carried objects as well as by exposure to the marine environment. The wheel from an NC-5 Mobile Electric Power Plant, Figure 5-43, clearly indicates weathering due to the sun, moisture and salt of the near Gulf environment of Pensacola, Florida.

5.6.2.17. Pitting of piston rods was much in evidence on GSE which remained for extended periods in "open skies" storage in near ocean atmosphere. An example is of the lift cylinder piston rod of an Aero 33D Bomb Truck in the storage yard at Key West, Figure 5-44. Many aircraft jacks from the full environmental range of their use were found to be similarly attacked by pitting corrosion. Hand rails of maintenance stands, tow bar handles, arm rests, in fact most areas where acid from hand contact exists on GSE show considerable pitting. The arm rest on a TA-75 Aircraft Tow Tractor, Figure 5-45, is typical of many such instances of pitting corrosion, (Key No. 17).

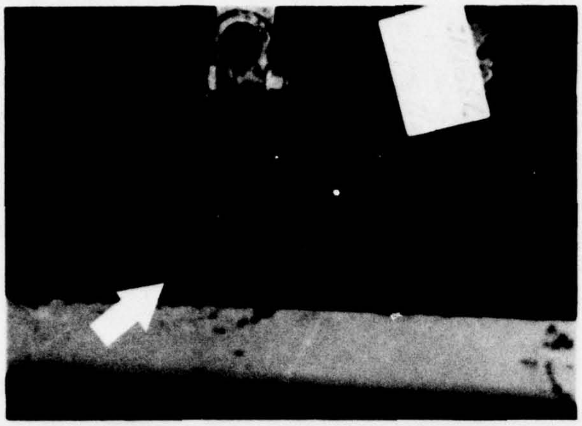

Figure 5-34. TA-18 Tow Tractor - Battery Compartment Corrosion

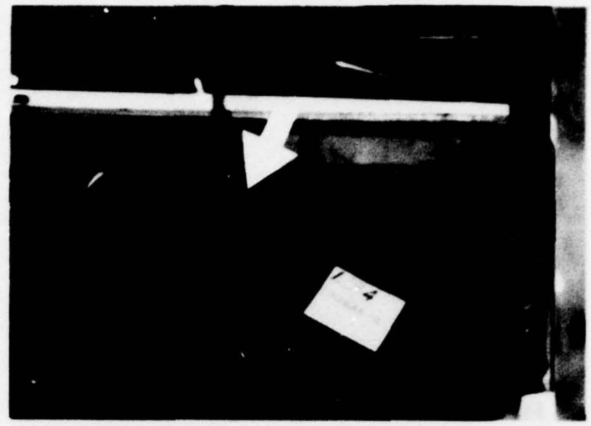

Figure 5-35. Mobile Electric Power Plant - Instrument Case Corrosion

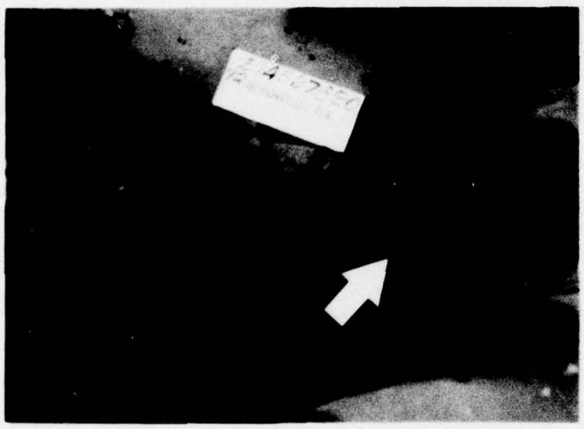

Figure 5-36. Engine Removal Trailer - Piston Rod Corrosion

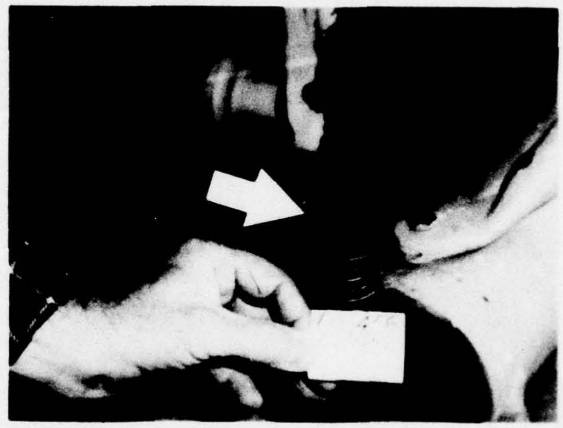

Figure 5-37. AERO 51-B Munitions Handling Trailer - Exposed Screw Unprotected

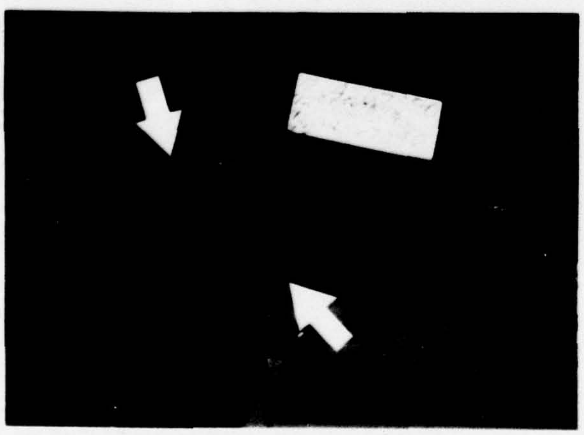

Figure 5-38. Seat Cushion from NC-12 MEPP - Design Deficiency

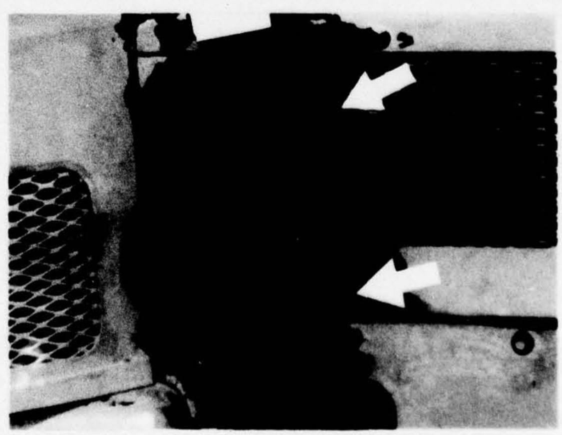

Figure 5-39. SATS Weapons Loader - Corrosion from Muffler

Figure 5-40. Air Start Unit from MD-3 Tow Tractor - Fatigue Crack in Frame

Figure 5-41. O_2 Charging Cart - Fitting Corrosion

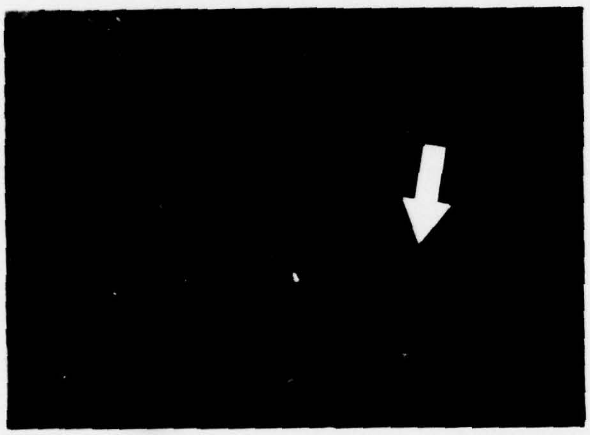

Figure 5-42. Weathered Surface Coating - MD-3 Aircraft Tow Tractor from Shipboard

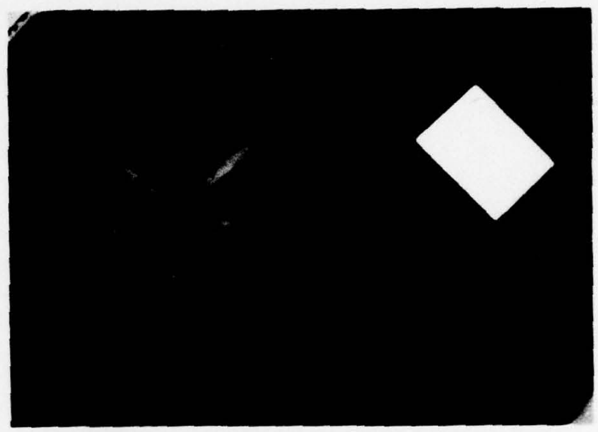

Figure 5-43. NC-5 Mobile Electric Power Plant Wheel - Effects of Weathering

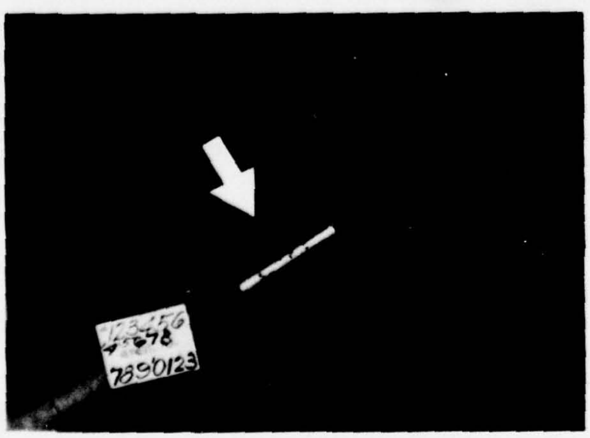

Figure 5-44. Aero 33-D Bomb Truck - Pitting Corrosion on Piston Rod

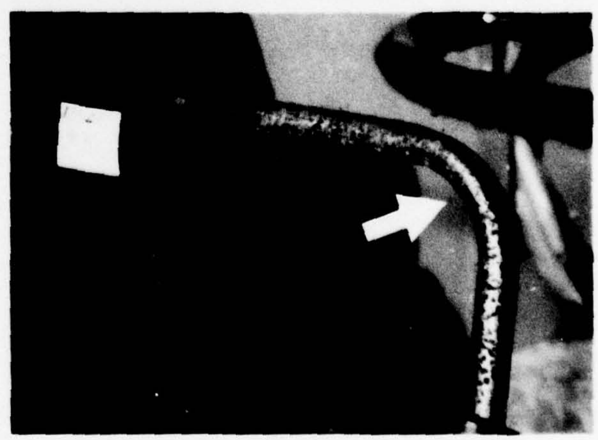

Figure 5-45. TA-75 Aircraft Tow Tractor - Pitted Arm Rest

5.7. An investigation into current state of the art corrosion efforts by the military, scientific and industrial communities is in process and will be evaluated in the final engineering report. A bibliography of sources of data under investigation is included in Appendix A.

5.8. A GSE Corrosion Photo Summary of East and West Coast Sites surveyed as well as survey photos from shipboard at end of a deployment is presented in Appendix B. The preponderance of photos made of East Coast equipment is indicative of a much greater corrosion susceptability in the Eastern near ocean environment. Humidity levels in the East are generally higher than those in the West at comparable latitudes and also there is a much higher salinity in the Atlantic than the Pacific Ocean, hence a higher airborne salt content. Corrosion control maintenance requirements generally are less stringent as the site, be it East or West, moves away from the Tropic to the temperate latitudes.

5.9. Publications covering items of ground support equipment surveyed are listed in Appendix C.

5.10. A listing of materials, processes and equipment investigated is presented in Appendix D. Findings from the investigation and evaluation will be included in a final engineering report of the project.

REFERENCES

(1) COMNAVAIRSYSCOM ltr. AIR-4117B/49: RSN of 8 Jun 1971 (NOTAL)

(2) NAVAIR 01-1A-509 Technical Manual Aircraft Weapons Systems Cleaning and Corrosion Control, Organizational and Intermediate, 15 March 1972

(3) NAEC-GSED-91 Control of Corrosion in Ground Support Equipment, Interim Report, June 1975

(4) MIL-STD-808 (USAF) Finishes, Protective, and Codes, for Finishing Schemes for Ground and Ground Support Equipment, October 1960

(5) MIL-T-704 Treatment and Painting of Materiel, October 1972

(6) "Analysis and Critique of Depot Level Maintenance Procedures for the Application of Protective Coatings to Naval Aircraft, "Final Report, Phase I Contract N62269-71-C-0308 by W.D. Benzinger & A.H. Fainberg, to Analytical Rework/Service Life Programs Office, Naval Air Development Center, December 1972

(7) NAVAIR 17-1-107 Technical Manual Aircraft Maintenance Aerospace Ground Support Equipment Work Unit Code Manual, 1 November 1972

(8) Uhlig, Herbert H., "Corrosion and Corrosion Control," 2nd Edition, John Wiley & Sons, Inc., New York, 1971

(9) Copson, H.R., "Long-Time Atmospheric Corrosion Tests on Low Alloy Steels", ASTM Proceedings, 60, 650-655 (1960)

(10) Southwell, C.R., Forgeson, B.W., and Alexander, A.L. "Corrosion of Metals in Tropical Environments, Part 2 - Atmospheric Corrosion of Ten Structural Steels", Corrosion, 14 (9), (1958)

(11) Coburn, K., "A Low Cost Maintenance-Free Structural Steel for Highway Applications", Highway Research Record 110 (1966)

(12) Alexander, A.L., Southwell, C.R., and Forgeson, B.W., "Corrosion of Metals in Tropical Environments, Part 5 - Stainless Steel", Corrosion, 17 (7), (1961)

(13) Copson, H.R., "Atmospheric Exposure of Nonferrous Metals and Alloys", ASTM Subcommittee VI, 1957 Test Program, Reprint from ASTM Proceedings 59, 61, 62 and 66 (1959, 61, 62 and 66)

(14) Southwell, C.R., and Alexander, A.L., "Corrosion of Metals in Tropical Environments - Part VIII. Nickel and Nickel-Copper Alloys", Materials Protection 8 (3), (1969)

REFERENCES (Continued)

(15) The Metals Handbook, Eighth Edition, Vol. 1, American Society for Metals, (1961) "The Resistance of Nickel and Nickel Alloys to Corrosion", Friend, W. Z.

(16) Copson, H. R., "Atmospheric Corrosion Behavior of Some Nickel Alloys", ASTM STP No. 175, (1956)

(17) Godard, H. P., "The Atmospheric Corrosion of Architectural Metals", The Engineering Journal, 36 (7), (1953)

(18) Southwell, C. R., Alexander, A. L., and Hummer, C. W., "Corrosion of Metals in Tropical Environments, Part 6 - Aluminum and Magnesium", Materials Protection 4 (12), (1965)

(19) Ailor, W. H., "Five-Year Corrosion of Aluminum Alloys at Several Marine Sites", British Corrosion Journal, 1, (1966)

APPENDIX A

BIBLIOGRAPHY

Anti-Corrosion Methods and Materials, Volume 21, June 1974

ZRC Products Cold Galvanizing Compound, December 1975

Buckeye Heavy Duty Cleaner for Automatic Machines, Low Foaming Detergent

MFG Permathane Rustite, Corrosion Preventive Coating

Millis Research, Materials, Thin Film Deposition and Development

Metco Flame Spray Equipment, "N" Gun Metallizing

Classifications of Corrosion Failures, Nalco Chemicals, December 1975

Electrocoating of Aluminum Components for the Navy Harpoon Turbojet Sustainer Engine, Teledyne

Dupont Hytrel, Butterfly Valves

Maintenance Engineering, Preventive Maintenance Painting, March 1975

Rulon and Teflon, High Performance Materials thru Formulation and Fabrication

MP159 Bolting, High Strength Corrosion Resistant Fasteners

Estane, B. F. Goodrich Chemical Company, Thermoplastic Polyurethane Compounds

Plastics Design Forum, Designing with Glass Reinforced Plastics, Nylon 6/12 Compared to 6/6, May/June 1976

Performance of Ten Generic Coatings During 15 Years of Exposure, AD-762 408, Naval Engineering Laboratory, April 1973

Observations of Corrosion Control Procedures Aboard Operating Carriers, NADC-MA-7122, N.A.D.C, April 1971

Study of Corrosion Protection Methods for GSE Applications at Kennedy Space Center, MAB 3221-69, May 1972

APPENDIX A (Continued)

Analysis and Critique of Depot Level Maintenance Procedures for the Application of Protective Coatings to Naval Aircraft, A.A.R.P., NADC, December 1972

Proceedings Naval Aircraft Materials and Processes Meeting, A.A.R.P., NADC, April 1973

Airborne Weapons Handling Equipment (Shipbpard), NAVAIR 19-100-2

Conversion Coatings, Manual 246, Materials Engineering

Surfaces Produced by Abrasive Blasting of Steel, Lt. C.B. Doherty, U.S. Coast Guard

The Mechanism of Corrosion of Polybutadiene-Coated Steel in Aerated Sodium Chloride, Volume 32, No. 2, February 1976

Technotes, NAESU, U. S. Naval Aviation Engineering Service, Philadelphia, Pa., January 1976

Naval Aircraft Avionics Corrosion Prevention and Control, A.A.R.P., NADC, January 1974

Triservice Corrosion Conference Abstracts, October 1974

The Corrosion of Metals in Marine Environments, Report 245, Defense Metals Information Center Batelle Memorial Institute, May 1970

Proceedings Naval Aircraft Materials and Processes, A.R.P., April 1974

Corrosion of Metals in Tropical Environments, NRL Report 7834, N.R.L., January 1975

Exfoliation Corrosion Behavior of 7 x 75 Aluminum Plate, AFML-TR-75-43, July 1975

1974 Triservice Corrosion Conference Volume 1, AFML-TR-75-42, September 1975

1974 Triservice Corrosion Conference Volume 11, AFML-TR-75-42, September 1975

Ground Support Equipment Corrosion, Report Bibliography, Search Control No. 019919

APPENDIX A (Continued)

Erosion of Ground Support Equipment, Report Bibliography, Search Control No. 041214

Corrosion of Ground Support Equipment, Report Bibliography, Search Control No. 041809

Controlling Factors in Galvanic Corrosion, W. A. Wesley, Proceedings ASTM, Volume 40, 1940

Preliminary Design and Cost Study of Recirculating Chromate Rinse System for Aircraft Corrosion Control, Report No. NADC-72183-VT, 2 November 1972

Observations of Potentials of Metals and Alloys in Sea Water - F. L. LaQue and G. L. Cox, Proceedings ASTM, Volume 40, 1940

Corrosion Abstracts, NACE, NTI Service, Springfield, Virginia 22151

APPENDIX B

GSE CORROSION PHOTO SUMMARY

WEST COAST SITE SURVEY

Site	Equip. Items Surveyed	Photos Taken	Incidents AV/Photo	Incidents AV/Equip. Item	Total Incidents Reported
AIMD, North Is. San Diego, CA	14	20	4	5	75
NARF, North Is. San Diego, CA	8	11	3	4	30
NAS Miramar San Diego, CA	22	31	3	4	83
MCAS El Toro Santa Ana, CA	14	19	2	3	44
NAS Moffet Field Sunnyvale, CA	8	19	3	6	51
NARF Alameda Alameda, CA	12	25	2	5	55
NAS Whidbey Is. Oak Harbor, WA	5	8	3	4	21
Total	85	133	20	31	359
AV/West Site	12	19	3	4	51

APPENDIX B (Continued)

GSE CORROSION PHOTO SUMMARY

EAST COAST SITE SURVEY

Site	Equip. Items Surveyed	Photos Taken	Incidents AV/Photo	Incidents AV/Equip. Item	Total Incidents Reported
Jacksonville, FL	39	135	4	15	576
Pensacola, FL	12	98	4	8	408
Whiting, FL	5	14	4	11	56
Keywest, FL	24	84	4	14	330
Beaufort, SC	18	101	4	21	381
Norfolk, VA	14	74	4	19	270
Oceana, VA	9	47	4	20	177
Total	121	553	28	108	2198
AV/East Site	17	79	4	15	314

SHIPBOARD SURVEY

Site	Equip. Items Surveyed	Photos Taken	Incidents AV/Photo	Incidents AV/Equip. Item	Total Incidents Reported
USS Independence	11	17	4	7	74

APPENDIX C

CORROSION RELATED SPECIFICATIONS, STANDARDS AND TECHNICAL MANUALS

Federal Specification:

TT-R-248	Remover, Paint and Lacquer, Solvent Type

Military Specification:

MIL-B-81744	Barrier Coating Solution, Lubricant Migration Deterring
MIL-C-16173	Corrosion Preventive Compound, Solvent Cutback, Cold-Application
MIL-C-19853	Carbon Removing Compounds, Agitated Tank
MIL-C-22750	Coating, Epoxy-Polyamide
MIL-C-26074	Coatings, Electroless Nickel, Requirements for
MIL-C-47044	Coating Conformal of Welded Modules, Process Requirements for
MIL-C-47164	Compound, Plastic Polyurethane
MIL-C-47244	Coating, Ablative Resistant
MIL-C-5410	Cleaning Compound, Aluminum Surface, Non-Flame-Sustaining
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-C-6799	Coatings, Sprayable, Strippable, Protective, Water Emulsion
MIL-C-81309	Corrosion Preventive Compound, Water Displacing, Ultra-Thin Film
MIL-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys

APPENDIX C (Continued)

Military Specifications (Continued)

MIL-C-81773	Coating, Polyurethane, Aliphatic, Weather Resistant
MIL-C-83286	Coating, Urethane, Aliphatic Isocyanate for Aerospace Applications
MIL-F-18264	Finishes: Organic, Weapons System, Application and Control of
MIL-G-9954	Glass Beads: For Cleaning and Peening
MIL-K-81576	Kit-Touch-Up, For Corrosion Control of Weapons Systems
MIL-L-46002	Lubricating Oil, Contact and Volatile Corrosion Inhibited
MIL-L-81352	Lacquer, Acrylic (For Naval Weapons Systems)
MIL-M-45202	Magnesium Alloys, Anodic Treatment of
MIL-R-3043	Resin Coating, Permanent, for Engine Components and Metal Parts
MIL-R-7751	Remover, Paint and Varnish (Silicate Type)
MIL-R-81294	Remover, Paint, Epoxy System
MIL-S-81733	Sealing and Coating Compound, Corrosion Inhibitive
MIL-S-8802	Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-Adhesion
MIL-T-704	Treatment and Painting of Material

Military Standard:

MIL-STD-808	Finishes, Protective, and Codes, for Finishing Schemes for Ground and Ground Support Equipment

APPENDIX C (Continued)

Technical Manuals:

NAVAIR 19-45-3	Mobile Electric Power Plant Diesel, NC-10A, Sun Electric
NAVAIR 19-45-8	Mobile Electric Power Plant Diesel, NC-10B, Sun Electric
NAVAIR 19-60-82	Mobile Air Conditioning Unit, NR-5C, Acme
NAVAIR 17-15BAB-33	Generator Test Set Land Base Model, MA-3, Avtron
NAVAIR 17-15BF-39	Hydraulic Test Stand Electric, AHT-63, Sun Electric
NAVAIR 17-15BF-55	Portable Hydraulic Test Stand Electric, AHT-63, Liquidonics
NAVAIR 17-15BF-56	Hydraulic Test Stand Diesel, AHT-64, Liquidonics
NAVAIR 17-15BF-66	Portable Hydraulic Test Stand Diesel, AHT-64, Teledyne
NAVAIR 19-1-92	A/C Cleaning Machine, Large
NAVAIR 19-1-105	A/C Spotting Dolly, SD-1D, Consolidated Diesel
NAVAIR 19-15-7	Adjustable Aircraft Maintenance Platform, B-4A
NAVAIR 19-15-8	Maintenance Platform Adjustable, B-5A
NAVAIR 19-15BA-39	Loader, Air Launched Weapons, A/S32K-1
NAVAIR 19-25B-15	Nitrogen Servicing Unit, NAN-2, Stewart Avionics
NAVAIR 19-45-10	Mobile Electric Power Plant, NC-2A
NAVAIR 19-45-17	Fire Fighting Equipment, TAU-2

APPENDIX C (Continued)

Technical Manuals (Continued)

NAVAIR 19-75AAC-10	Liquid Oxygen/Liquid Nitrogen Generating Plant, GB-1A, Cosmodyne
NAVAIR 19-75AAC-12	Liquid Oxygen/Liquid Nitrogen Generating Plant, GB-1A, Cosmodyne
NAVAIR -	Avionics Corrosion Control Study
NAVAIR 19-40-35	Aircraft Towing Tractor, TA-75A, United Tractor
NAVWEPS 19-45-2	Mobile Electric Power Plant, MMG-1, Electric Products
NAVAIR 19-45-4	Motor Generator, Mobile, MMG-2, Inet Power
NAVAIR 01-1A-509	Vacuum Blast and Cleaning Machines (Section VIII)
NAVAIR 19-15BE-4	Weapons Loader, Aero 47A, Standard Manufacturing

APPENDIX D

MATERIALS, PROCESSES AND EQUIPMENT UNDER EVALUATION FOR CORROSION CONTROL APPLICATIONS

MATERIALS

MATERIALS	MANUFACTURER	POTENTIAL USE
Fluorocarbon (TFE)		High Corrosion Resistance
Rigid PVC		Fastening Devices
90 Metals and Alloys	Techalloy Co., Inc.	
FRP Reinforced with "ATLAC" 382 Polyester Resin	Jones and Hunt, Inc.	Corrosion Resistant
Molykote Lubricant	Dow Corning Corp.	Corrosion Resistant

PROCESSES

PROCESSES	BY WHOM	POTENTIAL USE
Electroless Nickel Plating	Electro-Coatings, Inc.	High Corrosion Resistance for Critical Wear Areas
Shot Peening	Metal Improvement Co.	Corrosion Eliminator
Powder Coatings		Chemical and Heat Resistance
Lint-Off Coating	American Metaseal Co.	Minimize Accumulation of Lint
Flame Spraying	Metco Inc.	Corrosion Resistant Coating
Cold Galvanizing	ZRC Chemical Products Co.	Corrosion Control

APPENDIX D (Continued)

PROCESSES (Cont'd)		
PROCESSES	BY WHOM	POTENTIAL USE
Chartek 59 Coating	AVCO Corp./Systems Division	Corrosion Resistant Coating
"N" System Metallizing	Metco Inc.	Metal Repair
Air Coolant Systems	Vortec Corporation	
Metal Impregnation	Advanced Technology, Inc.	Corrosion Resistance
Disilicide Diffusion Coating	Society of Automotive Engineers, Inc.	Aerospace Material Specification
Liquid Salt Bath Nitriding	Society of Automotive Engineers, Inc.	Aerospace Material Specification
Surface Treatment of Polytetrafluoroethylene	Society of Automotive Engineers, Inc.	Aerospace Material Specification
Tin Plating, Immersion	Society of Automotive Engineers, Inc.	Aerospace Material Specification
Corrosion Prevention and Treatment Program		

EQUIPMENT		
EQUIPMENT	MANUFACTURER	POTENTIAL USE
Von Arx Needle Scaler	Marindus Company, Inc.	Corrosion Remover
Hydroblitz Washer	Hydro Systems Co.	Cleaner
Jenny Steam Cleaner	Homestead Industries	Cleaner
Air Electrostatic Finishing Systems	Nordson Corporation	Coating Applicators
Model 610E Hydroblaster		Corrosion Remover

CONTROL OF CORROSION IN GROUND SUPPORT EQUIPMENT (INTERIM)

NAEC GSED 106
A/T A340 0000/
051B/6F4146 1400

A summary of efforts to provide guidelines for control of corrosion of ground support equipment. Problem definition and "state-of-the-art" investigations include findings of surveys of East and West Coast NAS/MCAS/CV sites. A comprehensive Corrosion Key analyzes the extensive photographic record from the survey. Data has been compiled relating to corrosion control methods, materials and equipment for inclusion in a NAVAIR manual specifically oriented for GSE.

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